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VACANCY CHAINS AND INTRA-URBAN MIGRATION

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VACANCY CHAINS AND INTRA-URBAN MIGRATION

by

Donald C. Rundquist

A DISSERTATION

Presented to the Faculty of
The Graduate College in the University of Nebraska
In Partial Fulfillment of Requirements
For the Degree of Doctor of Philosophy

Department of Geography

Under the Supervision of Professor Dean S. Rugg

Lincoln, Nebraska

May, 1977
TITLE

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Geography is concerned with the description and explanation of locational patterns of static or moving phenomena on the surface of the earth. Human geography, therefore, is concerned with the description and analysis of locational patterns of static or moving phenomena of human origin on the surface of the earth.

Kevin R. Cox
1972
VACANCY CHAINS AND INTRA-URBAN MIGRATION

Donald C. Rundquist, Ph.D.

University of Nebraska, 1977

Adviser: Dean S. Rugg

American society is a very mobile one, with approximately twenty percent of the populace changing its place of residence every year. It has been estimated that over two-thirds of all moves take place within the city. Geographic studies of intra-urban migration generally treat the relocations as either 1) movement from one areal unit to another, such as inter-census tract flows, or as 2) individual-level, unrelated moves between respective origins and destinations. In reality, however, each change of residence is one part of a much longer sequence of changes.

This thesis examines intra-city moves within the framework of their real-world linkages by utilizing the concept of the vacancy chain. The work emphasizes the spatial manifestations and geometric character of intra-urban residential movement by using the vacancy chain to describe, analyze, and explain the patterns. More specifically, the research attempts to statistically identify intra-city "channels of migration," whose existence has been postulated by several scholars (though none has substantiated the notion). The study is based upon 1972 mobility data collected by three utility companies for Lincoln, Nebraska.
Principal findings of a geographic nature include the fact that 65.9% of the intra-urban changes of residence were 2.99 miles or less in length. In general, the length of a link was found to be inversely related to its position in the chain with the first "link" (the initial move to the urban periphery) being the longest. Similarly, there tended to be an inverse relationship between directional bias and link number with the angles of moves in central parts of the city being more "random" than those for the outer areas. The vacancies in the sequences of moves tended to "move" closer to the Central Business District and the level of "clustering" of the move-origins decreased as one moved further back in those sequences. The four statistics developed to quantify the geometric alignment of each vacancy chain allowed only 20.3% of the chains to be correctly grouped according to the neighborhood of origin. Therefore, the multivariate classification failed to substantiate the existence of "migratory streams" within the city.

The "housing-environment" analysis determined that 71.1% of the vacancy chains ended in census tracts that were below the mean dollar-value of the city's owner-occupied homes, with 58.5% terminating in tracts that were one standard deviation below the mean and 12.6% in tracts that were two standard deviations below average. The sequences, however, generally did not continue to the poorest areas of the city. In all, 72.7% of the movers migrated to a "better" housing environment, but the extent of the "upward-filtering" decreased as link number increased. "Reverse-filtering," then, tended to become more prevalent as chains lengthened. A statistically significant difference was found between the "upward-" and "downward-filterers" as the average level of increase for the former group was $10,105 while the decrease for the
latter group was only $5,059. The multivariate analysis of the "filtering indicators" allowed correct classification of 42.2% of the vacancy chains but much of the discriminatory power rested merely on the home values in the neighborhoods where the sequences originated.

The principal hypothesis of the dissertation, dealing with the statistical identification of intra-city "migratory streams," had to be rejected because the four developed spatial indices did not allow consistent and accurate grouping of vacancy chains. Despite this fact, the author believes that "vacancy-chain analysis" has great potential, especially for research involving large metropolitan areas.
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CHAPTER I

MIGRATION AND THE VACANCY CHAIN

Introduction

Migration, the movement of persons from one locality to another, is a geographical phenomenon that dates from the earliest days of the human race. Man seems to harbor an innate predilection for the occupation of new territory, whether for reasons of sheer survival or merely because of his insatiable curiosity about the landscape beyond the next horizon. Whatever the reasons, this earth has seen much human mobility with the passage of time. Numbers of migrants have ranged from the temporary and oft-repeated wanderings of small food-gathering or hunting parties through permanent moves due to climatic change to great masses of humanity migrating to avoid oppression. Man's "... history is indeed a chronicle of movement and change."\(^1\)

General Classification of Migration

Geographical Scale

Migration remains a strong force in many areas of the world. The necessity of understanding this pervasive process was recognized early, and many researchers have since attempted to study movement in a

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\(^1\) H. P. Chudacoff, "Men in Motion: Residential Mobility in Omaha, Nebraska, 1880-1920," Published Ph.D. Dissertation, Department of History, University of Chicago, 1969, p. 1
systematic fashion. The investigations generally treat migration as either: 1) inter-national--movement between nations; 2) intra-national--movement within one nation, such as rural-to-urban or inter-state migration; 3) inter-urban--movement between cities of one nation; or 4) intra-urban--movement within one particular city. The inter-national scale of movements has received the greatest attention in the literature, followed by intra-national, inter-urban, and intra-urban, in that order.

Permanence

The subject of human migration can be clarified further when considered in terms of two distinct temporal subdivisions--temporary and permanent movement. Temporary or frequent trips departing from and returning to the home include the journey-to-work, shopping and school trips, and social interaction. Permanent movements, on the other hand, refer to actual changes in the location of the home. This study focuses only upon permanent changes in one's residence.

Residential Mobility Within the United States

Levels of Movement

The permanent change of residence has long been a commonplace event in American society. The 1850 federal census, which represented the first attempt to measure the extent of residential mobility within the country, concluded that Americans were highly mobile.² This has since become a fact of life in the U.S. Since that 1850 enumeration, cities have continued to grow and the streams of migration, aided by a

²Ibid.
continually improving transportation technology, became vast rivers of human movement.

The Bureau of the Census has shown of late that 20 percent of the populace moves every year, and this rate has been remarkably uniform since 1947. The graph illustrated as Figure 1-1 points up the interesting fact that national events such as foreign wars, recession, and inflation have affected the mobility rate (1947-1968) very little. Other somewhat surprising statistics show that 50 percent of the population changes its place of residence in a five-year period, and that the average family moves eight or nine times during its existence as a unit—all indicative of our intense spatial mobility.3

A more recent study by the Census Bureau reveals that from March 1970, to March 1973, 31.8 percent of all U.S. residents moved.4 Consequently, the early 1970's reflect slightly higher mobility rates, although the economic slowdown of the mid-1970's casts some doubt on the prospect of that trend continuing.

Despite the large residential turnover, the inter-county and inter-state migrants accounted for only a small part of the total movers during the 1947-1968 period (Figure 1-1). In those years, only about 7 percent of all migrants went to another county, with approximately 3 percent of the moves being inter-state. Thus, about 10 percent of the movers were left unaccounted for. Vincent Barbara, Director of the Census Bureau, more recently suggested that only


**Figure 1-1**
(Source: Moore, 1972)
3 percent of all migrants move to another county and 3 percent move to a different state. Most changes of residence, then, actually cover little physical distance. Butler, et al., in a national survey, revealed the extent of this limited or "micro-migration," finding that slightly more than 60 percent of all moves are less than five miles in length. This general conclusion, which has been substantiated in many succeeding works, is a very important one for the geographer (as will be shown later).

Since inter-county and inter-state migrants account for only a small part of the total moves, most residential movement apparently takes place within the limits of large metropolitan areas. Herbert, in fact, estimates that over two-thirds of all moves are intra-city.

It is with this intra-urban residential mobility that the present study is concerned.

Generalizations Regarding Intra-Urban Residential Mobility

A thorough review of the literature regarding the subject of intra-city mobility can be confusing. The findings are varied and often contradictory. Several authors including Simmons, Abu-Lughod and Foley, Herbert, Johnston, and Moore have made attempts to consolidate a sizable portion of the research on mobility into one organized


treatise, but even this can leave the reader in doubt at times. Therefore, the following comments are intended to summarize briefly a significant amount of the literature on intra-urban migration by noting only the most salient and empirically verified of all the findings. References to other works related more directly to the evolution of the study are found in a succeeding section.

As stated above, many of the early censuses and academic investigations have shown statistically that we live in a mobile nation and that these rates remain fairly uniform. It is now understood, however, that one segment of the population accounts for these high rates of movement while another portion is rather sedentary. It is also self-evident that renters are more mobile than owners.


9 Sidney Goldstein, "Repeated Migration as a Factor in High Mobility Rates," American Sociological Review, Volume 19, October, 1954, pp. 536-541. The reader is also referred to other related works such as: Peter A. Morrison, "Duration of Residence and Prospective Migration: The Evaluation of a Stochastic Model," Demography, Volume 4, 1967, pp. 553-561, who, for example, substantiated the hypothesis that a person's propensity to move declines as his duration of residence increases. Morrison, "Chronic Movers and the Future Redistribution of Population: A Longitudinal Analysis," Demography, Volume 8, 1971, pp. 171-184 again substantiated the mover-stayer dichotomy indicating that mobility is largely a matter of habitual movers changing residence repeatedly and frequently. One of the conclusions of this latter study, which should be of interest to geographers, is that the spatial distribution of habitual migrants is uneven. For additional considerations of mover-stayer concepts, the reader is also referred to A. Speare, Jr., "Home Ownership, Life Cycle Stage and Residential Mobility," Demography, Volume 7, 1970, pp. 449-458, which casts some doubt on the inverse correlation between probability of moving and length of residence (or what has been termed the "axiom of cumulative
The most fundamental and outwardly obvious characteristic regarding intra-urban migration relates to distance. Researchers have concluded time and again that most movers actually traverse little physical distance when relocating. This is, of course, related to the individual's activity space since one has much better information on those localities that are closer to the original place of residence. This concept is well understood in view of the current behavioral concepts which have come to fore. 10

The other spatial characteristic of migration, directional bias, is not as clearly understood or empirically proven as distance bias. On a "a priori" basis, however, one would predict a general outward flow of migration away from the Central Business District, and this has been shown to account for the majority of moves. 11 In addition, the outward-trending movement of the populace with time is a basic assumption in two of the "classical models" of urban structure and growth. Burgess, for example, suggested that new in-migrants to the city would


10 An excellent review of basic behavioral concepts as they relate to mobility as found in Frank E. Horton and David R. Reynolds, "Effects of Urban Spatial Structure on Individual Behavior," Economic Geography, Volume 47, Number 1, January, 1971, pp. 36-48.

11 Johnston, 1971, op. cit., p. 320. Theodore Caplow, "Incidence and Direction of Residential Mobility in a Minneapolis Sample," Social Forces, Volume 27, May, 1949, pp. 413-417, also reported a slight tendency for families to drift outward toward the urban periphery.
locate in the transitional area near the urban core, and, after a period of economic and social acculturation, would move outward in a concentric fashion to more desirable areas. This outward progression was conceptualized as an on-going process represented by a positive relationship between socio-economic status and distance of residence from the Central Business District. Similarly, Homer Hoyt envisioned outward movement in his "Sector Model" despite the fact that the various class divisions of society were (in his model) arranged in the city in distinctive "wedges." His conceptualization suggested that the outward movement was caused by "filtering," the process whereby individuals of successively lower socio-economic levels occupy a given dwelling with the passage of time. In addition, the newer "factorial models" have shown that "family status" or the stage in the family life cycle, one of the three Shevky-Bell social-area constructs, is indeed a concentric phenomenon, i.e., as a family moves through its life cycle, the movement trend is generally away from the city center. The literature regarding this spatial characteristic, however, implies that more definitive work needs to be done.


A generally accepted fact concerned with the decisional aspects of residential mobility, and founded largely in the work of Rossi, is that the most important single determinant of a change of household location is the stage of the life cycle. Authors, again, have expounded upon the fact that housing needs change as one moves through the life-stages of single, young-married, parent, and grandparent, and that most moves occur in the early stages of the family history. Despite recent criticism by Morgan to the effect that Rossi tends to overestimate the influence of household size on mobility, this concept maintains a prominent place in the literature concerning the movement decision.

The "push-pull" framework has provided a satisfactory and time-worn means of organizing reasons for moving. "Pull factors," or the attractiveness of another location, might include such factors as a prestigious neighborhood, a secluded lot, proximity to a good school, the fact that the home under construction has a fireplace and two-car garage, or any number of other variables. Conversely, the push factors might include lack of space, a "degraded" condition of a dwelling or neighborhood environment, proximity to a noxious facility (railroad, interstate highway, airport, etc.), social composition of the neighborhood, the inaccessibility of the present location, and many more. It is important to reiterate Rossi's finding that the most moves stem from "push factors" - negative reactions to the present dwelling.

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15 Rossi, 1955, op. cit.
17 Rossi, 1955, op. cit.
Related to the push-pull variables is the concept of "place utility." Each resident retains a mental image or "list" of the advantages to be had at that particular location in space. This place utility is constantly changing as new input is added from the corresponding "action space." When one reaches a point where greater utility can be gotten from another location, one begins the considerations that lead eventually to the decision to seek an alternate residence.

These generalizations are deemed by the writer to be the most conclusive and empirically valid of the research completed to the present. With this material in mind, the study can proceed to a consideration of typical geographical approaches to intra-city residential mobility, followed by a detailed discussion of the approach to be used in this work.

Traditional Approaches Used for Geographical Research on Intra-urban Migration

Studies of intra-urban migration can also be classified in two other ways: 1) those that treat migration as movement from one areal unit to another and 2) those that consider exact points of origin and destination. The difference is in the level of analysis--"aggregate" versus "individual."


Aggregate-Level Analysis

While the aggregate approach has been rather popular in the literature, there are certain difficulties associated with it. For example, the choropleth map, which is often used for studies of this type, gives only broad indications of movement patterns and may give false impressions since moves within the areal unit cannot be shown.\(^{20}\)

In addition, if census data are used, the "turnover period" is ten years.\(^{21}\) Even if aggregated data for a one-year period can be obtained,


\(^{20}\) In other words, when the data are gathered, it is usually done by referring to a source that may reflect simply the fact that a different household now resides at a given address than did so at the time of the last check. The choropleth map would then show those areas (e.g., census tracts) that either gained or lost population, or those with the most new residents--again, only general patterns can be shown.

\(^{21}\) James P. Allen, in a book review of Stephan Thernstrom, The Other Bostonians, Cambridge: Harvard University Press, 1973, found in Economic Geography, Volume 51, April, 1975, p. 180, discusses some of the problems of using census data for mobility analyses. He also makes an interesting statement (p. 181) concerning Thernstrom's method of studying (individual level) social and residential mobility in Boston from the 1880's to the 1960's. Allen states: "The type of data used [Boston City Directories] is different from that employed by most geographers, and it is a refreshing change. I'm referring to the empirical base of individuals traced through time, as opposed to the usual procedure of aggregating data at different points in time but without any necessary continuity between the populations represented. One senses that the former provides a better grasp on the personal reality of the mobility situation and makes possible more concrete and powerful writing."
which is doubtful, movers who change residence more than once in any given year are not represented in the totals. Finally, "... it is being increasingly realized that aggregate level models do not possess a high degree of predictive power... "22 For these reasons, this type of approach is less than perfect.

Nonetheless, there are some advantages to the aggregate approach. First of all, data are often more readily available in aggregate form (e.g., the census) or can be transformed rapidly to that mode. Regarding the latter point, Census Bureau computer packages such as DIME (Dual Independent Map Encoding) allow the assignment of tract designations to individual street addresses to be done automatically, and the resultant aggregated data can then be mapped in choropleth fashion very easily through procedures such as SYMAP. Secondly, other variables such as socio-economic indicators as presented in census publications can be related to the tract-level movement patterns. Finally, aggregated data are readily adapted to mathematical modeling, although there are difficulties in those procedures (see source in footnote 22).

Individual-Level Analysis

Analyses using maps depicting origin-destination vectors are, on the other hand, much more revealing. There is, first of all, obviously a greater level of specificity, or what has been referred to as the "personal reality" of residential changes, in these maps (See footnote 21). The exact distance and direction—the spatial components—of each move can also be recorded. In addition, the migration can be considered in terms of any focal point in the city such as the CBD if so desired.

Finally, the nature of the environment at both origin and destination can be evaluated, either by personal inspection or through statistics that can serve as a surrogate for one's personal assessment.

In contrast to these advantages, though, there are also certain difficulties associated with the vector treatment which have no doubt limited its use in the past. The most obvious problem is, of course, the greater amount of time required in the mapping of the results since the exact location of individual addresses—both origin and destination—has to be first identified. This can be, and usually is, an exceedingly tedious proposition. Secondly, if all moves in a city were mapped in vector fashion, any significant results would surely be obscured by thousands of superimposed vectors. Because it is often difficult to ferret out any spatial patterns in the vector configurations, sampling is usually necessary—to reduce the number of mapped vectors but still allow geographical conclusions regarding the movement process. In sampling, a representative group of single moves is selected for mapping, thereby removing certain other moves, i.e., vectors, which are "tied" to those that were selected. This is perhaps the biggest defect of the vector approach—the fact that each move is treated as being unrelated to all others when in reality each individual change of residence is only one part of a much longer sequence of changes. Of course, if every intra-urban move that took place in a city during a certain time frame could be mapped, the vectors comprising these "sequences of changes" would naturally be included on the map. For reasons noted above, though, it is usually not feasible to map every single move that took place within a city. Consequently, while it is desirable to use sampling procedures, it would, at the same time, seem
logical to develop a means of examining changes of residence within the framework of their real-world linkages.

The Concept of the Vacancy Chain

Philosophy of the Technique

The innumerable residential relocations in a metropolis all have a common denominator—each represents a decision based upon numerous considerations. The end result of these myriad individual decisions is the residential pattern of the city at that point in time. Because the existing residential structure stems from these individual decisions, the writer submits that mobility should initially be studied in as much detail as possible. The search for spatial order and/or geographical generalization calls first for simplifying the complexity wrought by the many individual moves. In short, it is here contended that a more complete understanding of the "macro" spatial patterns can only come through detailed examination of many singular intra-city migrations, followed by gradual aggregation (at increasing scale). To accommodate these considerations, this writer proposes utilization of a variation of the vector technique here referred to as "analysis of vacancy chains."  

23 A vacancy chain is defined, for purposes of this study, as a series of related moves constructed by linking individual vectors which connect the origin and destination of each change of residence in the series. A vacancy chain consists of at least two vectors with the first link being an intra-urban move. The term is used synonymously with "linkages." A "Glossary," included as Appendix "A", provides the reader with a list of the terms (and their definitions) used in this vacancy-chain analysis.
Four events initiate vacancies in cities: 1) construction of a new dwelling unit; 2) a resident leaves the city (out-migration); 3) the death of an individual or a family unit; and 4) an intra-urban move. Each of these occurrences has a pronounced effect upon other parts of the city in that a whole chain of vacancies is created within the housing market. As an illustration, if a person residing at location "A" in a hypothetical city called "X" chooses to move to another city, a vacancy is created at location "A." (See Figure 1-2). Other persons in the city then have the opportunity to leave their current dwelling and move to that found at location "A." That is to say, the persons currently residing at "B," "C," and "D," all of whom are interested in location "A," now are competitors for that property. If the resident of location "C" outbids the others for location "A" and actually migrates to that point in the city, then a new vacancy is created at "C," for which others in the city will compete. In the illustration, an in-migrant from city "Z," and residents at locations "N," "R," and "M" now are the bidders for location "C." Note that the resident at "R" outbids the others and moves from that point to location "C." In similar fashion, the resident of location "E" competes with an in-migrant from city "Y" for the newly vacated location "R." The in-migrant is the high bidder and relocates at "R." Here, the intra-urban sequence of changes is halted because of the lack of continuing vacancy. So, when one person changes his place of residence by moving, a vacancy is created at his former address, which creates another, and so on. The housing supply is reallocated as people satisfy their housing needs. This is quite obviously a very dynamic and perpetual process, and one which warrants detailed examination.
SAMPLE VACANCY CHAIN IN A HYPOTHETICAL CITY

In-migrant from city Z

Figure 1-2

Corporate Limit of City X

In-migrant from city Y
Vacancy chains, which can be ferreted from mobility data and mapped within the spatial context of the city, are traceable, in the intra-urban sense, until termination. Chains can terminate in three general ways. In the first place, an intra-urban sequence of residential changes may be ended when an in-migrant—someone moving into the city—fills a vacancy in a given chain. Chain #1 in Figure 1-3 illustrates just such a situation. Note that Chain #1 is ended because no vacancy is left within city "B." Secondly, a vacancy chain may be terminated when a dwelling unit is removed from the housing stock. The unit at location "I" in Figure 1-3 has been destroyed by fire thereby ending the sequence here called Chain #2. Finally, vacancy chains can be terminated simply when no vacancy is left at a given point in a chain. One of the ways that this can occur is illustrated by Chain #3 in Figure 1-3. Here a divorce has occurred but one of the individuals has chosen to remain in the dwelling at location "J." Therefore, there are no further vacancies in Chain #3. In similar fashion, chains can be ended by marriage. Chain #4 depicts a situation where two young adults have left the parental home to form a new family. Since the parents of these individuals remain in the dwellings at locations "K" and "L," this particular vacancy chain cannot be continued. These, then, are examples of situations that cause termination of intra-urban vacancy chains.

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24Vacancy chains sometimes terminate in other ways, depending upon the nature of a particular study. For example, if the researcher has mobility data for a certain city for a period of one year, chains end when the vacancies are carried into the following year—for which no data are available. In this way, chains cannot be continued because the end of the data set is encountered. There are also other unique situations that terminate vacancy chains such as a student moving from a dormitory.
EXAMPLES OF REASONS FOR VACANCY-CHAIN TERMINATION

CHAIN #1

D

In-migrant to city B from city Z. No vacancy left in this chain (in city B).

CHAIN #2

E

Unit removed from housing stock due to fire. No vacancy left.

CHAIN #3

G

Divorce, one partner remains in dwelling. No vacancy left in this chain.

CHAIN #4

H

Former residence of marriage partner.

Young adult marries, forms new family. No vacancy left in this chain as parents still reside here.

Corporate Limit of City B

*Note - "N" signifies a newly constructed home on the urban periphery.

Figure 1-3
The vacancy-chain technique incorporates all the positive aspects of the detailed vector treatment discussed above, but most of all, it still allows analysis at the "micro" level. Environments at move-origin and destination can still be studied, but the scope of the view is extended with the vacancy chain. Instead of only two environments, several can be "tied together" in sequence thus giving the researcher a better opportunity to view not only movement behavior as reflected via spatial expression but also the process of residential "filtering" in detail.

The idea of "movement" of vacancies through a chain is actually founded in the concept of "filtering." As Harrison C. White has stated, the filtering hypothesis is "... quite vague ... " and "... has been described variously, but it generally refers to the tendency of houses over time to depreciate in value, eventually falling into the hands of families with lower incomes." While the previous statement by White is the view from the "housing side," the same idea can be expressed in terms of the individual mover rather than the dwelling unit. In this sense, one can view the underlying hypothesis as man moving in

order to better his housing conditions. According to this model, the majority of the changes of residence that a family makes should be to a dwelling that is "better" than the previous one. Abu-Lughod and Foley, for example, suggest that 60% of those who move within the same community are seeking to better their housing circumstances. In short, models of changing urban socio-economic structure are based upon upward social mobility whereby housing filters down. This process is both inherent in and elucidated by the vacancy chain.

In addition, the vacancy-chain approach gives the writer the intuitive feeling that more order is associated with analyses of sequences of moves. Rather than the many, seemingly disorganized vectors seen on maps, each move can be classified according to its place in the mobility system, e.g., "second generation" vacancies created by initial vacancies in a particular suburban area. So, although the vacancy-chain methodology still does not solve all of the difficulties associated with the more traditional single-vector approach, it does remedy the implication of unrelated moves since they can now be linked together to reveal greater detail concerning housing turnover.

From a geographical perspective, the movement patterns illustrated by vacancy chains hold much promise. Linkages that any one neighborhood has with the remainder of the city can be revealed. A major portion of the mobility system of an urban area can be checked at any point in time by focusing on one or two areas of initial vacancies.

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27 The term, "second generation," refers to the second vacancy in the sequency of moves. Vector "GJ" of Chain #3 in Figure 1-3 is an example.
and mapping the resultant vacancy chains. The researcher could, for instance, select the most prestigious neighborhood in a particular city—such as "The Knolls" in Lincoln, Nebraska—for analysis. It may be possible that new construction in The Knolls eventually benefits lower-income residents such as those in the "Malone" area of Lincoln by opening up more housing. The hypothetical vacancy chains shown in Figure 1-4 illustrate how the mapping of these linkages could reveal such interrelationships between two neighborhoods lying at opposite ends of a city's socio-economic continuum (like The Knolls and Malone). A map using the single-vector approach based on sampled data would never reveal such areal ties. It would appear, then, that an actual finding such as the hypothetical situation shown as Figure 1-4 surely ought to be considered in any future decision-making concerning a city's housing policy, especially in guiding suburban development.

The rental system of a city might be the subject of investigation by analysis of vacancy chains. One large apartment complex could be selected, all moves into its units recorded, and the associated linkages developed and mapped. Assuming that moves into rental units generally come from other rental units in the city, the system of flows related to that particular portion of the housing market can be analyzed by focusing on only one initial set of vacancies—in one apartment complex. If, however, the units are often taken by new in-migrants to the city, chains will automatically be terminated. In this case, the patterns of first residential location of the in-migrants can also be elucidated. Many possibilities exist in this area of research.

The vacancy chain also readily permits light to be shed on other related phenomena such as areal and temporal vacancy characteris-
HYPOTHETICAL VACANCY CHAINS RELATED TO INITIAL VACANCIES IN "THE KNOLLS" AREA
Lincoln, Nebraska

Figure 1-4
tics. These can be studied since each move obviously occurred at some point in time and thus has a date attached to it. One could map differential vacancy rates for various areas of a city to perhaps identify those that are beginning to decline as evidenced by long-term vacancies.

A significant aspect of using the vacancy chain to study intracity residential movement relates to the existing models of urban structure and form, viz., the Concentric Zone and Sector configurations.28 Because the nature or spatial character of mapped vacancy chains is one of linear sequences of linked moves, gross movement behavior should be more apparent. In addition, the more detailed view of the housing turnover process should either help confirm or deny the existence of particular spatial models since the filtering process is fundamental to the Burgess and Hoyt (Concentric Zone and Sector) models. As a result, the writer believes that the vacancy-chain approach is capable of allowing a more positive identification of the specific model(s) operating in a city. It may also be possible to gain additional insight into the mechanics of these "classical" models by studying vacancy chains.

Perhaps most importantly, though, with the use of the vacancy-chain procedures, the scale of investigation can now be considered to have an "intermediate step" rather than the "polarization" suggested by only the individual and aggregate levels. The linking of individual moves gives a "medial" level to investigate. This line of thinking, which gives one a greater feeling for mobility at all levels, is organized as follows. First, the individual move-vector can be examined. Secondly, these single moves can be combined into their respective

28 Burgess, 1925, op. cit. and Hoyt, 1939, op. cit.
chains—or spatial systems of moves. Finally, the overall or aggregate situation can be ascertained by studying the systems of chains. These various scales of investigation are obviously related, but only the vacancy chain permits a simultaneous view of them.

Previous Attempts at Chaining Moves

Other researchers have "chained" individual moves together, but through very different methods and with somewhat different intentions than those to be tested here. F. S. Kristof, a planner, utilized this technique in assessing the turnover of housing in New York City.\(^\text{29}\) He began his research with an interview sample of 64 initially occupied new units. Interviewers then visited the housing unit left vacant by the household that had occupied the new unit, and each successor household was also interviewed in the same fashion until the chain was broken either by a continuing vacancy, demolition of a house, etc. Kristof, from this very small—and admittedly not representative—sample, found that for every 10 newly constructed units in the sample, 24 families could adjust their housing circumstances—10 by moving into the new units and 14 by "filtering" up to better housing, i.e., moving into the dwellings which were vacated. He did not concern himself with the spatial manifestations inherent in the process.

A study by Lansing, Clifton, and Morgan of the University of Michigan also dealt with chains of moves in an effort to test the idea

that people filter up to better housing.\textsuperscript{30} The researchers used a very small number of moves from each of many U.S. cities, and interviewers questioned householders about their socio-economic characteristics. The primary concern of this study was to determine if poor people benefit indirectly by new construction, so the work (like Kristof's) was based solely on chains begun with new homes. The authors found that only 10 percent of all the movers in the chains were "poor." When they considered the income levels of individual in- and out-movers at the same dwelling, they found that 55 percent of the former had lower incomes than those they were replacing and 25 percent earned more. Thus, filtering accounted for a slight majority of the total moves.

A master's thesis, done by a geographer, also can be classified as an empirical study of the vacancy chain. Dzus's 1975 work, focusing upon the city of Windsor, Ontario, was "... conducted to determine the indirect effects of new, single-family housing construction in creating housing relocation opportunities in an urban housing market area through the housing turnover process."\textsuperscript{31} The author based his analysis upon 90 newly constructed single-family homes--and, therefore 90 vacancy chains. Much attention was given to the "multiplier effect," which is simply the total number of moves in a series of vacancy chains divided by the number of newly constructed units (or initial vacancies).

\textsuperscript{30} J. B. Lansing, C. W. Clifton, and J. N. Morgan, New Homes and Poor People, Survey Research Center, University of Michigan, Ann Arbor, 1969.

\textsuperscript{31} The thesis referred to, and discovered long after this present dissertation was begun, is Roman Dzus, "Residential Construction, Vacancy Chains, and Mobility Through Intra-Urban Space: A Case Study of the Windsor Metropolitan Area," Unpublished Master's Thesis, Department of Geography, University of Windsor, 1975, p. 147.
In other words, the multiplier effect refers to the generation of new opportunities, i.e., vacancies, in the housing market through the reallocation of units due to new construction. In "multiplier terms," Dzus found that 110 additional housing opportunities appeared and were consumed as a result of the 90 newly constructed homes (multiplier equals 2.22). One other related finding, perhaps more important from a geographical point of view, was that the location of the new construction does not have a significant impact on the multiplier effect.

In his introductory material, Dzus proposed to describe the migration flows and spatial patterns related to the Windsor vacancy chains. Two maps, with little accompanying discussion, comprised the geographical aspects of the study. Nevertheless, principal "geographical conclusions" included the fact that there was no difference in the mean distances from respective origin points for the Position #2 and #3 moves and that some directional bias was manifested in the form of two distinct housing markets in the city. While the work by Dzus is interesting and significant in terms of the housing-market analysis, the question of the spatial characteristics of the vacancy chains is left unanswered.

A second master's thesis in geography has also contributed knowledge concerning the vacancy chain. Romerill's (1975) study, which

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32 Dzus, Ibid., p. 41, distinguishes between a "local multiplier" and a "total multiplier." The former, 2.22, refers to the statistic that results when the affect of in-migration is excluded (200 vacancies for 90 newly constructed units). The latter, 2.49 in the Dzus study, includes in-migration (224 vacancies for 90 newly constructed units).

33 "Position #2" and "Position #3" refer to the second and third moves in a vacancy chain begun by new construction.
focused upon Hamilton County (Cincinnati), Ohio, is best classified as a housing-market analysis since the emphasis is on the impact of new residential construction. Romerill, whose stated research goal was "... to investigate the spatial operation of the new housing market," utilized 281 vacancy chains in testing 13 hypotheses. These 281 chains, consisting of 549 individual households, led to a multiplier of 1.95. In summarizing his principal findings, the author included:
1) a majority of households entering new unit additions were former local market occupants; 2) variations in chain length generally followed a hierarchial pattern with larger, higher-value units leading to the longest chains and smaller, lower-value units causing short chains; 3) systematic variations in both unit and household characteristics were noted (e.g., high quality, owned, single-family dwellings were encountered in early chain links with lower quality units and rentals dominating the advanced link positions); 4) the filtering process did operate within the new housing market, but it usually halted prior to reaching households in the lowest income categories; and 5) the new housing market operations tend, in a spatial sense, to conform to traditional notions of urban residential structure. Regarding this latter point, Romerill found that as chains increased in length, successive links were located closer to the CBD and the distance between units in a chain tended to decrease. Romerill provided three (single-vector) maps of moves—those to the new units, those to the vacancies created

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35 Ibid., pp. 2-3. The chains were built from mailed questionnaires.
by the initial moves, and those to the vacancies created by the "second" moves. There was no discussion of the spatial patterns of the movement except for the distance factor. 36

The studies cited above all examined vacancy chains with reference to the impact of new construction on the housing market. No one has attempted to utilize the concept to analyze the spatial aspects of intra-city movement. One geographer, Eric G. Moore, has called for an analysis of the vacancy chain. 37 Moore's suggestion, though, referred primarily to the possibility of gaining insight into the nature of the housing market. The reading of the article by Moore led directly to the current dissertation since it occurred to this writer that intra-urban vacancy chains should also have certain spatial characteristics.

A book review of the Lansing, et al. study (discussed above) acted as a further catalyst when J. F. Betak, the reviewer, had similar feelings about the spatial components of vacancy chains:

In looking at location of the dwellings in the metropolitan areas, the authors [Lansing, et al.] only treat the distance of the chain. The authors find that there is a tendency for sequences, as they get longer, to move closer to the center. However, we have no indication from their data whether the chains show particular directional biases or areal configurations. Yet, the evidence regarding the importance of personal contacts in the search for new housing, and the theoretical work on urban contact fields would lead us to believe that there should be very distinct patterns in the sequences of moves.38

36 Romerill, p. 108, noted that "... visual comparison is hampered by the complex movement patterns illustrated ... ." The maps showed only individual links rather than complete vacancy chains.


As a result, this present work focuses upon one important geographic question left unanswered by Lansing and his colleagues—that regarding the spatial pattern or form of the chains.

All of the studies on vacancy chains cited above used data based on personal interviews. While the spatial focus of the current work differs from previous ones, the study also differs with regard to the data base. Rather than utilizing the interview approach, the present work derived its chains by scanning a data file, thus greatly speeding up the process and making research such as this much more feasible. If this system of building sequences of moves is practical, it could have positive implications for local planning agencies. This research also differs in that chains will begin with an out-migration (inter- or intra-urban move from a certain house) as well as with new construction, thereby allowing a more complete coverage of the city.

This chapter has thus far established that the dissertation will: 1) employ the concept of the vacancy chain and 2) use these sequences of moves in attempting to solve spatial problems relating to intra-urban mobility. But the nature of the specific spatial problem to be investigated must also be brought to light.

Other Literature Related Directly to the Evolution of This Study

While the literature on migration as a whole is voluminous and that for intra-urban residential mobility is growing, the following paragraphs are aimed only at those few works which had a direct bearing upon the formulation of the current research topic. Certainly many others, not discussed in detail here but mentioned in the footnotes to
this section, were relevant to the development of the research.39

One of the earliest attempts at a conceptualization of the great
migrations was done by Ravenstein in 1885.40 After surveying vast
shifts of population as reported by the Census of 1881 in Great Britain,
Ravenstein concluded his research with several "laws," two of which are
significant to the present study:

Law #2 - It is the natural outcome of this movement of migra-
tion, limited in range, but universal throughout the
country, that the processes of absorption go on in the
following manner:
The inhabitants of a country immediately surround-
ing a town of rapid growth, flock into it; the gaps thus

39 In addition to the works discussed in the text, the reader is
referred to at least the following studies: R. D. McKenzie, "The Neigh-
borhood: A Study of Local Life in the City of Columbus, Ohio," American
Journal of Sociology, Volume 27, September, 1921, pp. 145-168; Andrew
W. Lind, A Study of Mobility of Population in Seattle, The University of
Washington Publications in the Social Sciences, Volume 3, Number 1, 
October, 1925; Elsa Longmoor, Elsa Schneider, and Earle F. Young, "Eco-
logical Interrelationships of Juvenile Delinquency, Dependency, and Soc-
ial Mobility: A Cartographic Analysis of Data from Long Beach, Califor-
nia," American Journal of Sociology, Volume 41, March, 1936, pp. 598-
610; Robert E. L. Faris and H. W. Dunham, Mental Disorders in Urban
Areas, Chicago: University of Chicago Press, 1939; Christopher Tietze,
Paul Lemkau, and Marcia Cooper, "Personality Disorder and Spatial Mobil-
Harvey J. Locke, Mobility and Family Disorganization," American Socio-
logical Review, Volume 5, August, 1949, pp. 486-493; Samuel Stouffer,
"Intervening Opportunities and Competing Migrants," Journal of Regional
Science, Volume 2, 1960, pp. 1-26; H. L. Ross, "Reasons for Moves To and
From a Central City Area," Social Forces, Volume 40, Number 3, March,
Social Forces, Volume 11, March 1933, p. 351-367; Georges Sabagh,
Maurice D. Van Arsdale, Jr., and Edgar W. Butler, "Some Determinants of 
Intrametropolitan Residential Mobility: Conceptual Considerations," 
Social Forces, Volume 48, 1969, pp. 88-98; and Samuel Stouffer, "Interven-
ing Opportunities: A Theory Relating Mobility and Distance," Amer-

40 E. Ravenstein, "The Laws of Migration," Journal of the Royal
Statistical Society, Volume 48, 1885, pp. 167-235 and Volume 52, 1889,
pp. 241-301.
left by the rural population are filled up by migrants from more remote districts, until the attractive force of one of our rapidly growing cities makes its influence felt, step by step, to the most remote corner of the Kingdom. Migrants enumerated in a certain centre of absorption will consequently grow less with the distance proportionately to the native population which furnishes them . . .

Law #4 - Each main current of migration produces a compensating counter-current.

The whole concept of the vacancy chain is similar to Ravenstein's hypothesis of "step-by-step movement" whereby the movement of one person leaves a "gap" to be filled by another (Law #2). Of course, Ravenstein's migrants were not moving solely within metropolitan limits as they are in the present work, but the concept is similar. It is interesting, too, that Jansen notes that "... Ravenstein's ... thesis on migration by stages has never been adequately verified."41 Law #4 leads this writer to wonder whether or not there are migratory currents and counter-currents within the city as Ravenstein has postulated for the rural-to-urban situation. If so, this would mean that regular patterns or intra-urban "channels" of movement should become apparent.

In supplementing the work of Ravenstein, Lee noted that few additional generalizations have been advanced since the 1880's.42 Lee began his study by discussing four factors which influence the act of migration, and he followed by offering eighteen hypotheses which are grouped under three general headings. One group, "Stream and Counter-stream," holds particular promise for the geographer because of the

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spatial connotations. Lee's related hypothesis, which surmises that migration tends to generally occur within well-defined streams, would seem to support notions expressed earlier regarding Ravenstein's Law #4.

The two previous authors referred to migration in a more general sense, but Duncan Timms provided further stimulus for the current research when he made the following statements in an intra-urban context:

The residential movement of individuals and groups is highly systematic. As a result of the existing structure of the residential system and of the positive feedback induced by patterns of information flow, residential mobility is channelled in particular directions.43

These words again reflect the feeling that migration, in terms of its geography, occurs in an orderly manner.

Geographers have also implied, some more directly than others, that distinct migratory channels exist within the city. Building upon certain spatial-behavioral tenets of migration was John Adams, whose work concerning the concept of sectoral mental maps suggests regular movement patterns.44 Adams' basic premise, which was founded in the original mental-map concept as espoused by Peter Gould, is that the mental image of an urban area that one possesses is biased directionally.45 The sectoral image proposed by Adams runs from the downtown...

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area through the adjacent slums and the home neighborhood to the suburbs. He reasoned that this wedge-shaped image is apparent because urban residents are more likely to find peripheral areas beyond their home more desirable than the older districts nearer the CBD, yet they are familiar with all areas in that one sector because of their travel which is predominately along radial routes—either to the CBD or to suburban shopping centers. Adams hypothesized that one's activity space is primarily in one sector of the city, and therefore, if a residential change is made, it will be within that particular sector. The hypothesis was tested using three Minneapolis samples and directional bias was confirmed for long moves, while short moves were found to be random in direction.

A study done in 1969 by Ronald Boyce hinted at an answer to the question of the channelization of intra-urban migratory streams when the author stated that "... residential movement within Seattle is complicated by short moves among and between areas in a complex network of feeder and receptor areas." Boyce, who utilized public-utility data to examine residency changes in Seattle for the years 1962 through 1967, found that movement patterns do differ according to housing-value types. Regarding this point, Boyce stated:

In the Negro central areas movement is mostly internal ... Movement out of the area is highly restricted and channelized to nearby and newly forming Negro areas. By contrast, most other low value and middle value housing areas are best characterized as having a star-burst pattern. The dominant type of move in both cases seems to be to the next higher housing value rather than any suburban movement.

The high value housing moves are highly directed, but primarily to other high value areas rather than to suburban areas ...

The general movement among high housing value areas is a cross-town pattern.\textsuperscript{47} These findings suggest that vacancy chains should be configured in a discernible spatial pattern within a city.

A geographical work by Curtis Roseman dealing with the concept of migratory streams played a significant role in the development of this thesis.\textsuperscript{48} Roseman showed that interpersonal contacts in the form of family and friendship networks are a primary consideration in the locational decision of the potential migrant. He analyzed the spatial flow of information leading migrants from the rural South to choose a particular urban destination in the industrial Midwest. Because of these networks of information flow, the author hypothesized the existence of strong channels of migration between certain origins and destinations whose citizens have experienced interpersonal ties. Roseman's simple statistical model did reveal the hypothesized channelization. While the study of inter-urban ties done by Roseman is indeed intriguing, the research cited above implies that channelization should manifest itself within the city as well as between cities. It would appear that interpersonal contacts and information flow are important in both cases.

A review of the literature on the subject of intra-urban migration has revealed several "gaps" in our understanding of that process. From a geographical point of view, it seems that little knowledge of the spatial configurations of intra-city movement has been accumulated,

\textsuperscript{47}Ibid.

except for that regarding the prevalence of a "distance bias." Many researchers allude to certain "geographical patterns" of moves, but empirical evidence is minimal and overriding generalizations are lacking. As was suggested in the preceding paragraphs, several scholars have implied that regular "channels of migration" exist within the city. References to this phenomenon include Ravenstein's "currents" and "countercurrents" of migration, Lee's statement that migration tends to occur within well-defined streams, and Timms' feeling that "mobility is channelled in particular directions."49 It must be remembered, however, that Timms was the only one of the three that was addressing intra-urban mobility directly. The work of certain geographers, including Boyce who stated that "... there appears [emphasis mine] to be a complex network of channels and flows within and among areas ...," supports the notion of migratory channels.50 Betak felt that "... there should be very distinct patterns in the sequences of moves."51 Dzus, using vacancy chains in Windsor, found some directional bias in the form of two distinct housing markets, one on either side of a main thoroughfare.52 Curtis Roseman, though, is the only scholar to attempt to statistically verify and map migratory channels.53 Unfortunately, his analysis dealt only with inter-urban movement.

50 Boyce, 1969, op. cit., p. 25.
51 Betak, 1974, op. cit.
52 Dzus, 1975, op. cit.
53 Roseman, 1971, op. cit.
Statement of the Problem

As Brown and Holmes have indicated, considerable past attention has been directed to identification of migration variables and residential site selection models, but "... relatively little attention has been given to the spatial patterning and geometrical aspects of intra-urban migrations." The present study emphasizes the spatial manifestations and geometric character of intra-city movement by using the vacancy chain to describe, analyze, and explain the patterns. More specifically, the research attempts to statistically either confirm or deny the existence of intra-urban "channels of migration." If pronounced routes of movement do exist within the city, it should be possible, using clustering algorithms, to group vacancy chains that originate in several peripheral neighborhoods on the basis of certain spatial and/or housing-environment characteristics. In a more general sense, the work is intended to answer three other types of questions:

1. What geographic/geometric characteristics are identifiable from the first detailed maps of intra-urban vacancy chains for an American city and from a spatial analysis of those chains?

2. Are there significant differences in the housing environments at the various positions in the sequences of vacancies to adequately substantiate the filtering hypothesis?

3. Is the vacancy chain a meaningful and useful concept to use in geographic research on intra-urban migration and does it help clarify the spatial and/or social aspects of the process?

CHAPTER II

APPLYING THE VACANCY CHAIN TO THE PROBLEM

Elements of Application

Introduction to the Methodology

Each day thousands of households change their place of residence within the limits of the large metropolitan areas of the country. The urban geographer and the planner are concerned with this process of intra-urban migration since it does result in a change of the urban spatial structure, and more specifically, it changes the makeup of existing residential neighborhoods.

As Herbert notes, the "... study of intra-city mobility is but recently developed and has comparatively few firm concepts."\(^1\) Residential mobility only now beginning to receive the attention it deserves although it is an extremely important aspect of urban growth.

This research emphasizes what has been called the "clearly distinguishing feature" of migration—residential movement in space.\(^2\) In studying the phenomenon of intra-urban migration, a spatial analysis as well as a housing-environment analysis of vacancy chains within the city of Lincoln, Nebraska, is attempted in order to evaluate the


utility of focusing on sequences of moves to examine intra-city movement. The methodology for accomplishing this goal is discussed in succeeding paragraphs.

The Study Area

The capital city of Nebraska, located in the southeastern portion of the state about 55 miles southwest of Omaha, was selected as the "laboratory" for this investigation (see Figure 2-1). Lincoln is small enough to make the mobility data manageable—since all intra-urban moves in a city have to be first listed for linkage construction—and yet large enough to allow meaningful generalizations. The 1970 Census reported a population of 149,518 in the corporate area with 167,972 in the urbanized area. The 51,469 dwellings were 58% owner-occupied, 37% renter-occupied, and 5% vacant. The writer felt that Lincoln would prove an interesting study area since so much of the previous research on intra-urban residential mobility has focused on much larger cities.

3 1970 Census of Population and Housing, Lincoln Nebraska Urbanized Area.

LINCOLN AND THE REGION

Figure 2-1
Data Sources

The most difficult part of any study of residential mobility in the U.S. is generally the acquisition of suitable data. In the search for these data one is first tempted to utilize the publications of the Bureau of the Census, but this source is inadequate as it considers only aggregate moves into and out of specific counties and cities with no account of intra-urban flows. Consequently, if one is interested in precise origin-destination data, the census statistics are not suitable.

Common data sources for analyses of residential mobility in the United States include Polk directories, telephone directories, electoral registers, and school records. The compilation of move data from these sources is a very time-consuming and exhaustive process, and the accuracy of the acquired data is sometimes questionable. In addition, each of these data sources has its own particular bias. Polk directories, for example, are published once a year, therefore eliminating all "multiple moves" within the period of that year, and since they are compiled through a door-to-door canvass, many residents are missed totally if they are not at home during the survey. In using these directories in the past, the writer has found them to be somewhat incomplete.  

The best data source in this country appears to be public utility connection records. The data for this present study, provided

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5The author has no personal experience using telephone directories, electoral registers, and school records as data sources, but they are not highly recommended by Eric G. Moore, "Residential Mobility in the City," Association of American Geographers, Commission on College Geography, Resource Paper Number 13, 1972, p. 47.

6Ibid.
by the Credit Bureau of Lincoln, Nebraska, originated from three such sources—Lincoln Electric Service, Lincoln Telephone and Telegraph, and Cengas. Each of these organizations forwards the daily connection records to the Credit Bureau, where names are cross-checked and duplicates eliminated. The Credit Bureau then publishes the information in the form of the "Daily Moving Record" (See example on following page).

The "Daily Moving Record" certainly must compare very favorably to other data sources as it is a combination of records from the three utility companies. However, this source, too, has its biases. Because many large apartment buildings leave power and gas on in all units at all times, even when unoccupied, the "Daily Moving Record" is biased toward the individual homeowner and thus tends to underestimate renters. Therefore, if a renter does not desire a telephone, his presence in the city may not be recorded.

In addition, the use of the "Daily Moving Record" does not allow one to accurately distinguish the "owner-occupiers" from the "renters." Of course, this type of difficulty surfaces when using most data sources (except for the personal interview), so the "Daily Moving Record" is not unique in this regard. When a given street address on the move record is followed by a unit number, the assumption is probably that the resident of that unit is a renter. But this can be a misinterpretation since it is possible that the owner of a multiple-unit structure might occupy one of the units himself. On the other hand, if a street address is listed and is not followed by a unit number, one is likely to assume that the resident is the owner. This latter judgement may also be inaccurate since many families rent single-family dwellings. In short, the use of the "Daily Moving
<table>
<thead>
<tr>
<th>Name</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baumert Carol A</td>
<td>1201 J</td>
<td>3340 Y</td>
</tr>
<tr>
<td>Boor Ray B</td>
<td>309 No 32</td>
<td>3239 R</td>
</tr>
<tr>
<td>Brekke Diana J</td>
<td>6302 Platte</td>
<td>2205 No 30</td>
</tr>
<tr>
<td>Brown Thad M</td>
<td>3006 T</td>
<td>2912 N #4</td>
</tr>
<tr>
<td>Coleman Richard</td>
<td>1032 J</td>
<td>315 H</td>
</tr>
<tr>
<td>Crow Gary L</td>
<td>5610 Wilshire</td>
<td>2913 No 51</td>
</tr>
<tr>
<td>Epp Carol A</td>
<td>3728 So 52</td>
<td>3502 So 51</td>
</tr>
<tr>
<td>Fox Michael T</td>
<td>1626 D</td>
<td>4838 Meredeth #305</td>
</tr>
<tr>
<td>Fritzler D K</td>
<td>2726 E</td>
<td>2125 A #6</td>
</tr>
<tr>
<td>Gillies Richard D</td>
<td>8105 Cobblestone</td>
<td>8010 Hickory</td>
</tr>
<tr>
<td>Golden Edward</td>
<td>3715 Everett</td>
<td>3760 Everett</td>
</tr>
<tr>
<td>Hamm Philip S</td>
<td>1222 So 14</td>
<td>3179 R #2</td>
</tr>
<tr>
<td>Huenink Diane F</td>
<td>6432 Leighton</td>
<td>7200 Holdrege</td>
</tr>
<tr>
<td>Jorgensen Paul</td>
<td>4915 Cleveland</td>
<td>1235 So 22 #6</td>
</tr>
<tr>
<td>Kaiser Philip J</td>
<td>1626 D</td>
<td>4722 Judson</td>
</tr>
<tr>
<td>Kirkendall Kenneth</td>
<td>6819 Colfax</td>
<td>3436 No 48</td>
</tr>
<tr>
<td>Kunkee Michael H</td>
<td>2915 No 53</td>
<td>6903 Colby</td>
</tr>
<tr>
<td>Larmer R M</td>
<td>600 No 15</td>
<td>1201 J #400</td>
</tr>
<tr>
<td>Marcum Gwen V</td>
<td>1335 No 47</td>
<td>6037 Baldwin</td>
</tr>
<tr>
<td>Maxfield Lawrence W</td>
<td>5310 W Superior</td>
<td>5231 W Superior</td>
</tr>
<tr>
<td>Newkirk Robert</td>
<td>4600 Briar Park</td>
<td>2507 Krottingham</td>
</tr>
<tr>
<td>Porter Eileen</td>
<td>1703 No 65</td>
<td>2016 So 45</td>
</tr>
<tr>
<td>Ropers Arlene</td>
<td>1716 E</td>
<td>1027 Garfield #3</td>
</tr>
<tr>
<td>Schlegel William</td>
<td>3400 X</td>
<td>3419 X</td>
</tr>
<tr>
<td>Thompson Mary Jo</td>
<td>600 No 15</td>
<td>1120 No 14 #303</td>
</tr>
<tr>
<td>Wardyn Kathleen</td>
<td>1130 So 16</td>
<td>1230 H #3</td>
</tr>
<tr>
<td>Way Robert E</td>
<td>912 So 17</td>
<td>4330 Madison</td>
</tr>
<tr>
<td>Wenke Margaret Mrs</td>
<td>1860 Dakota</td>
<td>7221 South #9</td>
</tr>
<tr>
<td>Zajcek Larry</td>
<td>926 C</td>
<td>4011 So 32</td>
</tr>
<tr>
<td>Zook Robert</td>
<td>1430 So 20</td>
<td>4900 Mathis</td>
</tr>
<tr>
<td>Hlavac William</td>
<td>4000 Cornhusker</td>
<td>Hickman NE</td>
</tr>
<tr>
<td>Isbell W W</td>
<td>1860 Dakota</td>
<td>1727 No 54 Omaha NE</td>
</tr>
<tr>
<td>Johnsen Kain L</td>
<td>2020 G</td>
<td>Rt 1 Roca NE</td>
</tr>
<tr>
<td>Nichols Connie S</td>
<td>2925 L</td>
<td>Lake Quiviera KS 66106</td>
</tr>
<tr>
<td>Schutts N Philip</td>
<td>1335 No 47</td>
<td>3031 So 70 #109 Omaha NE</td>
</tr>
<tr>
<td>Stimson Leonard M</td>
<td>916 No 8</td>
<td>Roca NE</td>
</tr>
<tr>
<td>Tomka Anna Mae</td>
<td>541 So 18</td>
<td>3822 California Omaha NE</td>
</tr>
<tr>
<td>Weyers Walt</td>
<td>1035 No 53</td>
<td>4580 E Bails Denver CO 80222</td>
</tr>
</tbody>
</table>

**INCOMING**

<table>
<thead>
<tr>
<th>City</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>2502 Q</td>
</tr>
<tr>
<td>Bloomfield NE</td>
<td>1617 So 27</td>
</tr>
<tr>
<td>Brookings SD</td>
<td>2035 Griffith</td>
</tr>
<tr>
<td>Omaha NE</td>
<td>1914 Jefferson</td>
</tr>
</tbody>
</table>
Record" precluded a detailed consideration of owners versus renters and therefore, discussion concerning changes in tenure that occur at the various positions in the sequences of moves may be subject to a margin of error.

With regard to the actual construction of the vacancy chains, no problems were encountered in working with addresses for single-family dwellings, but the "Daily Moving Record" tended to be inconsistent with regard to addresses for multiple-unit structures and trailer parks. The inconsistency is related to the frequent lack of a complete address--the apartment-unit number or trailer-park lot number--on the data lists. A "spot check" of ten of the largest apartment complexes and trailer parks in Lincoln allowed an evaluation of the prevalence of this inconsistency in the data. The ten apartments, first of all, had 439 moves into their 988 units during 1972 (Appendix "B," Table 1). Of these 439 moves, 28 (6.4%) had no apartment number given for the new residential location. These same apartment complexes had 537 "families" move out during the year, but for 455 (84.7%), the complete address of the location they were leaving was not given. The same trend is seen in the data for ten large trailer parks in Lincoln comprising 648 total lots (Appendix "B," Table 2). There were 120 moves into the mobile-home parks during 1972 with 11 (9.2%) of the listed moves not containing a complete address. A total of 137 moves out of the parks were recorded and 130 of these (94.9%) were without the complete address for the location being vacated. While the omissions were a definite handicap in constructing vacancy chains (example given in "Procedures" section), the complete addresses were, in most cases, eventually discovered through cross-checking the original "Daily
Moving Record" with the computer lists, telephone directories, and city directories. The data inconsistency affected the study only in the sense of causing a greater expenditure of time for chain construction since it could not be done by computer and it was also necessary to consult other sources (directories).

The origin of this data inconsistency lies largely at the credit bureau itself. After all the data were gathered, keypunched, and computer-listed (so that the problem could be detected), the author inquired about the difficulty. While it was learned from credit-bureau personnel that the utility companies do not always provide complete information, it was determined that much of the blame is caused simply because the credit bureau is more interested in where a person moved to than where he came from. Because the "Daily Moving Record" is subscribed to by certain solicitation agencies, the personnel in charge of listing the names and addresses of the migrants tend to emphasize move destinations at the expense of move origins.

A reading of the above paragraph concerning the "complete" address might cause one to ask about the overall quality of the "Daily Moving Record" as a data source for analyses of intra-urban migration. Familiarity with the data record leads the author to state that for the "usual" procedures—that is, not using vacancy chains—it is excellent. In other words, for studies where the street address alone is sufficient, as it is in most mobility research designs, this data source for Lincoln is the most convenient, reliable, and complete to be found. Unfortunately, because the construction of a vacancy chain always requires the precision of a "complete" address for a multiple-unit structure, the data source lacks somewhat. Improvement in the
data record can only come through more careful and persistent information-gathering on the part of the three utilities involved and a greater effort by the Credit Bureau to provide the most detailed move record possible.

The data file for this study, then, was compiled from the "Daily Moving Record" for Lincoln, Nebraska. All move records for 1972 were obtained and all moves into, out of, and within the city of Lincoln for that year were recorded. These 19,239 moves comprise the initial data base.

The only other data used are "housing indicators" derived from the 1970 U.S. Census. These data, discussed in detail later in the work, consist of information on housing in the residential blocks "contacted" by the mapped vacancy chains.

Procedures

The Initiator Cells

Six "initiator cells" were selected on the periphery of the city of Lincoln (see Figure 2-2). Each is in the newer, expanding, more affluent sections of the city. These cells, which constitute major portions of six different census tracts—11, 12, 38.02, 38.01, 27.02, and 36.02—are considered by the author to comprise six distinct "neighborhoods"—"Bethany," "Meadowlane," "Wedgewood," "Trendwood," "College View," and "The Knolls." They were selected primarily because of their positions in urban space—on the suburban fringe with

7 An "initiator cell" is a contiguous set of sample blocks which constitute all or part of a census tract. It is taken to be representative of a "neighborhood." Moves to the initiator cells are used to "initiate" vacancy chains. A glossary of "vacancy-chain terminology" is found in Appendix "A."
LINCOLN AND THE INITIATOR CELLS

Figure 2-2
two of the cells being located north of "O" Street, Lincoln's main street, and four south of that thoroughfare (see Figure 2-2). Regarding the location of these cells on the fringe of the city, it should be noted that most of Lincoln's growth in recent years has been to the east and southeast. Another major consideration in the selection of these particular areas to serve as the initiator cells for this study was the fact that each is rather homogeneous in nature consisting mainly of single-family, owner-occupied dwellings.

While the six initiator cells contain a degree of homogeneity with reference to predominant house-types, there are, at the same time, some distinct differences among these neighborhoods (see Table 2-1). First, the average value of the owner-occupied homes ranges from a low of $19,000 in Bethany to a high of $42,300 in Trendwood. Meadowlane is near the low end of the scale ($20,300), followed by College View ($25,300), and Wedgewood ($28,600). The average home in The Knolls was valued at $36,000 in 1970 (see footnote to Table 2-1). A similar trend is seen when the average number of rooms for the owner-occupied homes is considered. Here, the values range from 5.6 rooms for Bethany to 7.5 for Trendwood. The average contract rent paid in 1970 reflects the same pattern as Bethany was lowest ($116) and Trendwood was highest ($256). The rank-ordering of the initiator cells is altered somewhat when the average number of rooms occupied by renters is reviewed, but again, Bethany renters had the fewest rooms (4.5) and Trendwood the most (6.3). In terms of population characteristics,

8 The Knolls was added to the study because of the curiosity of the writer as to the pattern of vacancy chains related to the place to live in the city of Lincoln.
**TABLE 2-1**  
SOCIO-ECONOMIC COMPARISON OF CENSUS TRACTS CONTAINING INITIATOR CELLS

<table>
<thead>
<tr>
<th>Initiator Cell and Census Tract</th>
<th>Owner Average Value (Dollars)</th>
<th>Owner Average Number of Rooms</th>
<th>Average Contract Rent (Dollars)</th>
<th>Renter Average Number of Rooms</th>
<th>Percent of Total Population Under 18 Yrs.</th>
<th>Percent of Total Population 62 Yrs. and Older</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bethany (11)</td>
<td>19,000</td>
<td>5.6</td>
<td>116</td>
<td>4.5</td>
<td>39</td>
<td>6</td>
</tr>
<tr>
<td>Meadowlane (12)</td>
<td>20,300</td>
<td>6.0</td>
<td>130</td>
<td>5.4</td>
<td>46</td>
<td>3</td>
</tr>
<tr>
<td>Wedgewood (38.02)</td>
<td>28,600</td>
<td>6.5</td>
<td>155</td>
<td>4.7</td>
<td>44</td>
<td>3</td>
</tr>
<tr>
<td>Trendwood (38.01)</td>
<td>42,300</td>
<td>7.5</td>
<td>256</td>
<td>6.3</td>
<td>42</td>
<td>3</td>
</tr>
<tr>
<td>College View (27.02)</td>
<td>25,300</td>
<td>6.2</td>
<td>136</td>
<td>5.1</td>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td><em>The Knolls</em> (36.02)</td>
<td>36,000</td>
<td>6.5</td>
<td>-</td>
<td>-</td>
<td>44</td>
<td>4</td>
</tr>
</tbody>
</table>

Source: 1970 Census of Housing, Lincoln, Nebraska Urbanized Area.

*Because the neighborhood (and initiator cell) called "The Knolls" comprises only a small part of Census Tract 36.02, these figures refer only to those blocks actually included within the initiator cell. In addition, much of this area was under construction in 1970 so the census data were not available for several of the blocks used. As a result, the statistics, especially the rather low average value of owned homes, may not present an accurate picture of this very affluent area. The initiator cells here called "College View" and "Wedgewood" encompass virtually all of Census Tracts 27.02 and 38.02 respectively. The "Bethany," "Meadowlane," and "Trendwood" initiator cells constitute the major portions of Tracts 11, 12, and 38.01, and the statistics provided in the table are considered by the author to present an accurate picture of those neighborhoods.*
similarities are seen in the percentage of the total population that is less than 18 years of age. Bethany had the lowest percentage of youngsters (39%) and Meadowlane the highest total (46%). While Meadowlane had a relatively high percentage of persons under 18 in 1970, it was one of three neighborhoods that had only 3 percent of the total population 62 years or older. College View (7%) and Bethany (6%) apparently had the greatest proportion of elderly residents.

While there are similarities among the six initiator cells, there are also distinct differences. The greatest variation appears to lie in the housing-value (range=$23,300) and the rent-paid (range=$140) statistics. The average numbers of rooms mirror these latter indicators. The population characteristics, on the other hand, appear more similar.

The original research plan called for the establishment of a system of initiator cells at the geographic center of each of the 1970 census tracts for Lincoln. The study was actually begun in this manner, but the procedure was eventually abandoned for several reasons. First, a troublesome "redundancy of chains" was frequently encountered. As an illustration of this problem, consider the following example as depicted in Figure 2-3. Assume that a series of sample initiator cells (1 through 10) were distributed throughout a hypothetical city called "F." If one begins to build vacancy chains associated with the more-central locations, the aforementioned "redundancy" problem becomes apparent. Consider vectors "C," "N," and "Y" as "foundation
EXAMPLES OF "REduDANT" VACANCY CHAINS

Figure 2-3

Corporate Limit of City F
ingsessions" into Initiator Cell "7." Because these initial moves create other vacancies in the city, moves "D," "O," and "Z" occur later and are subsequently tied to the initial moves. The result is three vacancy chains called "CD," "NO," and "YZ." This seems fine until one begins to record the foundation ingressions into Initiator Cell "4" where move "B" is recorded. It turns out that the vacancy created by move "B" led to moves "C" and "D," which are already a matter of record. At this point, it is learned that vacancy chain "CD," previously noted is in reality part of a larger chain called "BCD." The exact same situation has led to chain "XYZ" associated with Initiator Cell "5" in the hypothetical example. The situation worsens when foundation ingressions "A," "L," and "W" are recorded for Initiator Cell "2." Then and only then do the complete intra-urban chains surface. Chain "BCD" is really "ABCD," chain "NO" is "LMNO," and "XYZ" is "WXYZ." When this situation is repeated a hundred or more times, it soon becomes apparent that all of these same vacancy chains would have resulted by focusing on only one initiator cell, #2 in this case. The others are not needed to derive the three sample vacancy chains used in the illustration. This problem of chain redundancy caused the author to establish only six initiator cells as such, but they do cover nearly the entire growing fringe of the city of Lincoln. The chains resulting from these large peripheral initiator cells "contacted" virtually all parts of the city.

9 A "foundation ingress" is the intra-urban move into the initiator cell which initiates the vacancy chain. It can be caused either because of a previous change of residence involving (i.e., from) an initiator cell or new construction. It is the first "link" in a vacancy chain. (The term "link" is more properly defined in a succeeding footnote).
The second reason for choosing six initiator cells versus many more in all parts of the city is related to the very nature of the vacancy chain. Because cities grow by accretion on the periphery, the greatest proportion of new construction is obviously found there. Vacancy chains are most logically begun in that same area, which is probably why all of the previous works on vacancy chains were based solely on new construction located on the urban fringe. 10 If initiator cells are to be distributed throughout the city, one need not even use vacancy chains. Inter-neighborhood flows could easily be shown with single vectors leading to the various cells. The work with the data and maps for this study has led the author to conclude that there is no basis for using a vacancy chain if they are to be initiated in all parts of the city.

Thirdly, the vacancy chain best serves as an organizing concept for mobility analyses when the initiator cells are limited to the periphery of the city. Thus "Link 1" is always a move to the peripheral cell. 11 If more-central initiator cells were to be used, Link 1 for a central cell (for example, vector "C" in the previous diagram) would


11 A "link" is an individual vector in a vacancy chain. It is the straight line connecting the points of origin and destination (shortest path) of one intra-urban move. Links are numbered beginning with the "foundation ingresson" to an initiator cell, which is Link #1.
have to be compared to Link 1 of the peripheral cell (vector "A")
during the analysis (when vector "C" is really the third link of chain
"ABCD"). The approach is more systematic when using only peripheral
cells.

The final reason for the selection of six large initiator cells
rather than numerous small ones relates to the sheer mechanics of
vacancy-chain construction. As will be discussed in more detail in
succeeding paragraphs, the more-central areas of Lincoln are largely
within the rental market. Therefore, if initiator cells were to be
established in that area, it would be very difficult to complete chains
by linking moves since once a chain reaches the rental market, the
likelihood of the chain continuing is greatly reduced.

Detailed Explanation of the Derivation of Vacancy Chains

When this research topic was originally formulated, it was
hoped that all aspects of the linking of moves into vacancy chains could
be done by a computer scan of addresses in the data file. But problems
in the completeness of every entry on the data source, which were noted
above, precluded this methodology. Therefore, all searching for spe-
cific addresses leading to the construction of linkages was done manu-
ally, after some initial computer sorting.

The first step in the actual research was to organize all of
the moves into a workable format. Therefore, after all entries on
each edition of the "Daily Moving Record" were keypunched and verified,
the cards were read onto a tape and then subjected to an alphabetiza-
tion subroutine. The data were then printed out into a list organ-
ized by move destination. An example of a portion of the list
follows as Table 2-2.
TABLE 2-2

ALPHABETIC-BY-NUMERIC LISTING OF MOVE DESTINATIONS

<table>
<thead>
<tr>
<th>Date</th>
<th>From:</th>
<th>To:</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 14 72</td>
<td>2710 Vine</td>
<td>4821 Leighton</td>
</tr>
<tr>
<td>06 20 72</td>
<td>329 So. 29</td>
<td>4844 Leighton</td>
</tr>
<tr>
<td>09 30 72</td>
<td>Omaha N</td>
<td>4848 Leighton</td>
</tr>
<tr>
<td>07 11 72</td>
<td>405 No. We. 18</td>
<td>4926 Leighton</td>
</tr>
<tr>
<td>10 18 72</td>
<td>1940 So. Cotner</td>
<td>5011 Leighton</td>
</tr>
<tr>
<td>12 22 72</td>
<td>4502 Baldwin</td>
<td>5142 Leighton</td>
</tr>
<tr>
<td>05 09 72</td>
<td>6823 Garland</td>
<td>6902 Leighton</td>
</tr>
<tr>
<td>02 26 72</td>
<td>Ashland N</td>
<td>7301 Leighton</td>
</tr>
<tr>
<td>04 07 72</td>
<td>2301 A</td>
<td>4119 Lenox</td>
</tr>
<tr>
<td>10 21 72</td>
<td>7218 Logan</td>
<td>4214 Lenox</td>
</tr>
<tr>
<td>10 28 72</td>
<td>Homestead Fla.</td>
<td>4040 Lewis</td>
</tr>
<tr>
<td>06 15 72</td>
<td>8132 Deweese</td>
<td>5200 Lexington</td>
</tr>
</tbody>
</table>

etc.

The vacancy chains used in this work were built by careful examination of successive destinations. As an illustration, suppose address "Z" (below) were within an initiator cell, as shown by the hypothetical street grid, and a move into location "Z" occurred during the time period under investigation. Further, if the origin of that particular move was location "Y," then location "Y" will be a destination for a later move, unless the chain is halted for various reasons previously discussed (in Chapter 1). So the moves into both "Z" and "Y" can be found in the alphabetized listing of destinations.
The first step in the chain-construction procedure was to note the range of addresses included within each block of each initiator cell. In an effort to maintain both as much accuracy as possible and a systematic procedure, one recording sheet was utilized for each "initiator block."\textsuperscript{12} The blocks were identified by their census designations. A portion of the recording sheet for Block 116 of the Wedgewood Initiator Cell follows as an example:

\begin{quote}
\textbf{Wedgewood--Block 116}

Block 116 is bounded by the following streets:
A) Cherrywood  
B) Maplewood  
C) Cottonwood  
D) East Cherrywood

The street numbers included within Block 116 are:\textsuperscript{13}
A') 8000's - odd numbers (on Cherrywood)  
B') 7941 through 8000's - even numbers (on Maplewood)  
C') 200's - even numbers (on Cottonwood)  
D') 100's and 200's - odd numbers (on East Cherrywood)
\end{quote}

The range of street numbers for each of the 155 initiator blocks in the six initiator cells was determined by detailed reference to the 1972 edition of the Polk Directory for the city of Lincoln.\textsuperscript{14}

Next, the computer listing showing moves organized by destination (portion shown above as Table 2-2) was scrutinized and each move

\textsuperscript{12} An "initiator block" is one of the sample blocks in an initiator cell.

\textsuperscript{13} In Lincoln, the odd-numbered addresses are on the south and west sides of streets while the even numbers are on the north and east.

\textsuperscript{14} Part III of the Polk Directory is called the "Street and Avenue Guide." In this section, the numbered streets are arranged in numerical order, followed by the named streets in alphabetical order. The numbers of residences are arranged in numerical order and the names of intersecting streets are given to denote ends of blocks.
into addresses within individual initiator blocks was recorded as shown below:

<table>
<thead>
<tr>
<th>Date</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>A) 06 02 72</td>
<td>1128 Washington</td>
<td>8021 Cherrywood</td>
</tr>
</tbody>
</table>

(See "A" & "A" above)

Once the "cell ingressions" into each initiator block were all identified and recorded, it then became a matter of checking the data list for possible linkages. In the example immediately above, one must treat "1128 Washington" as a destination in searching for a move tied to the "first" move to "8021 Cherrywood." Those cell ingressions that could be linked with another move became foundation ingressions.

It should also be noted that when vacancy chains are being developed, the dates of the moves are very important. The move constituting the second link of a chain, for example, must have occurred after the date of the first. In other words, a situation such as the following cannot constitute a vacancy chain (even though the addresses might match):

---

15 A "cell ingressions" is an initial move into an initiator cell. It may be intra-urban, intra-state, inter-state, or even inter-national. If the intra-urban ingressions leads to the construction of a vacancy chain, it is then referred to as a "foundation ingressions." If it does not, it is simply termed a "non-foundation ingressions" to a particular initiator cell.
Obviously, one cannot move from location "X" to location "Y" in a city until a vacancy has been created at location "Y," and in the example (immediately above), the vacancy was not created until July 8th.

At each step during the linkage construction, the addresses involved were checked as to type of dwelling, i.e., whether they were of the single-family, apartment, or mobile-home variety. This was done quite simply because one move involving a multiple-unit structure or trailer park cannot be matched with another to build a chain unless the correct apartment number or mobile-home lot number, i.e., the complete address, is known (see earlier discussion). An example of a situation where the lack of a complete address caused a problem follows below.

Referring back to the sample foundation move in the example (above), it was learned that "8021 Cherrywood" was a single-family unit while "1128 Washington" was a twelve-unit structure. This was further elucidated when the address, "1128 Washington," was checked in the computer list of destinations (right-hand column below), which contained the following:

<table>
<thead>
<tr>
<th>12 09 72</th>
<th>3440 So 46</th>
<th>1128 Washington</th>
</tr>
</thead>
<tbody>
<tr>
<td>07 15 72</td>
<td>895 Elmwood</td>
<td>1128 Washington #11</td>
</tr>
<tr>
<td>08 18 72</td>
<td>329 So. 27</td>
<td>1128 Washington #12</td>
</tr>
<tr>
<td>08 22 72</td>
<td>Ogallala N</td>
<td>1128 Washington #4</td>
</tr>
<tr>
<td>09 08 72</td>
<td>1545 R</td>
<td>1128 Washington #7</td>
</tr>
<tr>
<td>12 02 72</td>
<td>Hartington N</td>
<td>1128 Washington #7</td>
</tr>
<tr>
<td>09 08 72</td>
<td>Omaha N</td>
<td>1128 Washington #8</td>
</tr>
<tr>
<td>06 13 72</td>
<td>3340 L</td>
<td>1128 Washington #9</td>
</tr>
</tbody>
</table>

---

16 Individual addresses were checked against the 1971 and 1972 Polk Directories for Lincoln and the "Listing of Multiple-Unit Structures in Lincoln," published by the Office of the Housing Administrator, February 9, 1974.
Because of the great number of moves into "1128 Washington" during 1972, it became necessary to ferret out the correct apartment number.

If the apartment number or trailer-park lot number was not listed on the move record, as in the case of the move involving "1128 Washington," then the individual's name as given in the "Daily Moving Record"—in this instance, "Richard C. Bruhn"—was checked in the Polk Directories. In this example, the directory (1971, p. 72) contained the following information:

Bruhn, Richard C. (Dianne)
Greenskeeper, Hillcrest Country Club
1128 Washington Street, Apartment 9

The computer list of destinations was then again consulted, and the second link was found. Consequently, the chain took this form:

<table>
<thead>
<tr>
<th>Date</th>
<th>Address 1</th>
<th>Address 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>06 02 72</td>
<td>1128 Washington #9</td>
<td>8021 Cherrywood (foundation)</td>
</tr>
<tr>
<td>06 13 72</td>
<td>3340 L</td>
<td>1128 Washington #9 (link 2)</td>
</tr>
</tbody>
</table>

This particular chain was then terminated because the "L"-Street address was not contained in the computer list of destinations, which suggested that it remained vacant for the rest of the year. So, while there was a move into the Washington-Street location during 1972 allowing a second link, there was none (detected by the utility companies) into the "L"-Street unit, meaning that the chain ended with two links.

The proper apartment number for an individual cannot always be obtained from the Polk Directories. For example, the following series of linkages also resulted from a foundation move into Block 116 of the Wedgewood Initiator Cell:

<table>
<thead>
<tr>
<th>Date</th>
<th>Address 1</th>
<th>Address 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>03 25 72</td>
<td>2800 Woods Blvd #1206</td>
<td>212 Wedgewood (foundation)</td>
</tr>
<tr>
<td>05 07 72</td>
<td>4532 So. 47</td>
<td>2800 Woods Blvd #1206 (link 2)</td>
</tr>
<tr>
<td>06 07 72</td>
<td>1525 F</td>
<td>4532 So. 47 (link 3)</td>
</tr>
</tbody>
</table>

The "F"-Street address proved to be an apartment with ten units, and since the number was not given on the "Daily Moving Record," the Polk
Directories were consulted. It was determined that the individual mover in the latter residential change was "Perry G. Worster." The 1971 version of the directory listed:

Worster, Perry G.
Plumber, Morrissey's Plumbing
435 N.W. 20 Street

While in the 1972 directory:

Worster, Perry G. (Pamela L.)
Plumber, Morrissey's Plumbing
4532 So. 47

Thus, while the 1971 directory listed Mr. Worster as residing at an address other than that noted in his intra-city move of June 7, 1972, the 1972 volume had him residing at his newer South 47th Street address. In this case, it was not possible to obtain an apartment number needed to continue a vacancy chain. 17

The examples of vacancy chains discussed above are intended to outline the procedures used in constructing the linkages to be studied in this work. While the rather detailed procedure described above points out the very cumbersome mechanics of manual vacancy-chain construction, it also elucidates the difficulties associated with residential changes involving multiple-unit structures because of inconsistencies in the data.

17 It should be noted that in cases such as this where the needed apartment number was not available in the Polk Directories, the Lincoln Telephone Directories were also consulted. In a few instances, the needed information was obtained from the latter source.
Statistics for Analyzing the Linear Characteristics of Vacancy Chains

Because of the fact that the vacancy-chain approach to analyses of residential mobility is rather new, it was decided that certain analytical techniques designed especially for vacancy chains were needed. Established linear-analytic procedures such as geographic "network analysis," as discussed by Haggett and Chorley, were generally not applicable to this particular spatial entity. Consequently, it became evident that statistical means for describing and analyzing the geographic orientation of a vacancy chain had to be devised. The resulting measures consider several important aspects of vacancy chains--e.g., the physical spacing of links in a chain, its linear "path," and the relation of the chain to the CBD.

Chain Spacing

One of the descriptive statistics developed to assist in the examination of vacancy chains, termed the "Spacing Index," attempts to provide a measurement of the actual spacing between residences in a particular chain. This index is simply an adaptation of the well-known variance statistic--in this case, the average variance of the lengths of individual vectors about the mean for one chain. Thus, there is one coefficient calculated for each chain of vectors. The formula is:

18 Peter Haggett and Richard Chorley, Network Analysis in Geography, New York: St. Martin's Press, 1969.
\[ Sp_j = \frac{1}{N_j} \sum_{i=1}^{N} (x_i - \bar{x})^2 \]

where: \( Sp = \) the Spacing Index

\( x_i = \) each individual link distance in one chain

\( \bar{x} = \) the mean link distance of all links in one chain

\( N_j = \) the number of intra-urban links in a chain

The following examples illustrate the concept of the Spacing Index:

Example 1:

Here, \( Sp = 0 \), i.e., perfect spacing

Example 2:

Here, \( Sp = .25 \), i.e., fairly regular spacing
Example 3:

Here, \( Sp = 3.06 \), i.e., not regular spacing

The examples on this and the previous page point up the fact that a high index means that there were great differences in the actual physical distances of links in a particular chain, and a low index shows regularity in the distances traveled. But a fairly significant problem had to be resolved regarding this quantitative measure—just what is a "high" and a "low" index, i.e., what exactly is meant by "regular" spacing? For quantitative measures to be truly meaningful, the verbal description should coincide with the quantitative description. With no prior vacancy-chain precedent to refer to, the task of applying "verbal synonyms" to the various quantitative values was a formidable one. After studying hypothetical configurations in terms of their calculated Spacing Indices, it was decided that those indices that were below .25 would be termed "regular," those between .25 and .99 "fairly regular," and those above 1.00 "not regular." The values may seem rather low and the requirements somewhat stringent, but the determination was made with the city of Lincoln in mind. It seems that this classification may require alteration with regard to the size of the city in which application of the technique is being made.
Chain Sinuosity

The second statistic adapted and added to the analysis of vacancy chains is here called "Migration Sinuosity" and is a measure of the path wandering of the chain. Like the Spacing Index, it is also based upon the distance component of the residential changes. The statistic, an adaptation of stream sinuosity, merely relates the actual path of the links in a chain to the length of the expected path. Consequently, there is one coefficient calculated for each chain of vectors. The formula is:

\[ S_i = \frac{A_{ij}}{E_{ij}} \]

where: \( S_i \) = the Index of Migration Sinuosity

\( A_{ij} \) = the actual length of the combined links in a chain

\( E_{ij} \) = the length of the expected path of a chain, i.e., the straight-line distance from the last vector origin in a chain (i) to the destination of the foundation move (j)

The following examples illustrate the concept of the Index of Migration Sinuosity:

\(^{19}\) Ibid., p. 58.
Example 1:

Here, \( A = 5 \text{ miles} \)
\( E = 5 \text{ miles} \)
Therefore, \( S_i = 1.00 \), i.e., there is no difference between \( A \) and \( E \)--no sinuosity.

Example 2:

Here, \( A = 5.5 \text{ miles} \)
\( E = 5.4 \text{ miles} \)
Therefore, \( S_i = 1.02 \), i.e., there is little difference between \( A \) and \( E \)--low sinuosity.

Example 3:

Here, \( A = 8 \text{ miles} \)
\( E = 2.8 \text{ miles} \)
Therefore, \( S_i = 2.86 \), i.e., there is much difference between \( A \) and \( E \)--high sinuosity.
After establishing the Sinuosity Index as an operational tool, it again became necessary to establish "levels of importance" for the computed values. A review and comparison of hypothetical vacancy chains, their geometrical configurations, and the calculated indices led to the decision that chains with a Sinuosity Index less than 1.25 would be said to have "low sinuosity." Similarly, those chains with coefficients lying between 1.25 and 1.50 became "somewhat sinuous," while all chains above 1.50 were "sinuous." Again, application of the technique to a much larger city would surely necessitate a change in these ordinal groups.

Azimuth Differential

The position of a vacancy chain with regard to the CBD was also deemed an important consideration. It occurred to the writer that in the case of a chain with a low Spacing Index and low Migration Sinuosity, one need only compute an angular measurement for Link 1 in order to obtain the overall alignment of a particular chain. In other words, if one had a hypothetical chain such as that shown below, where both "Sp" and "Si" are low, a small angular differential between Link 1 and a "CBD angle" fixes the orientation of the chain with respect to the CBD.
The problem then became one of actually measuring an "azimuth differential." The simplest solution seemed to be to take the absolute difference between the Link-1 origin-destination azimuth and an azimuth struck from the Peak Land Value Intersection to the Link-1 destination. Diagrammatically, this would be represented as:

\[ A_d = | a - b | \]

or effectively,
\[ A_d = c \]

In assigning "verbal synonyms" to facilitate the discussion of the Azimuth Differentials for the derived vacancy chains, 15-degree groups were settled upon after consideration of the angular possibilities and their meaning with regard to the urban structure of Lincoln. Therefore, an Azimuth Differential of 15 degrees or less is termed "CBD-oriented" while those between 16 and 30 degrees are "somewhat CBD-oriented" and others are "not CBD-oriented."

**Direction of Gain**

The "Direction-of-Gain Index," developed by the author, is utilized to assess the contribution to peripheral growth made by a
vacancy chain leading to a given initiator cell. The measure is based upon the difference in distance from the Peak Land Value Intersection of the city in question to the destination of the first link and to the origin of the last link. Again, one coefficient is computed for each chain. The formula is:

\[ D_g = V_{pi} - V_{pj} \]

where: 
- \( D_g \) = the Direction-of-Gain Index
- \( V_{pi} \) = the vector distance in miles from the Peak Land Value Intersection (p) to the destination of the first link in a chain (i)
- \( V_{pj} \) = the vector distance in miles from the Peak Land Value Intersection (p) to the origin of the last link in a chain (j)

The following examples illustrate the concept:

In the example, \( D_g = 5.2 - 2.2 \)
\( D_g = 3.0 \) miles

which indicates that the chain, as a whole, contributed to peripheral growth.
In this example, $D_g = 5.0 - 6.5$ and $D_g = -1.5$ miles, which indicates that the chain, as a whole, contributed a central-city gain. Thus, a positive value of the index indicates that the chain contributed to peripheral growth, and the higher the value, the greater that contribution. A negative value represents a total central-city gain. In other words, a positive value means that, as a whole, movers in a particular chain are moving outward from the CBD, presumably to better quality housing.

In keeping with the practice of assigning "verbal synonyms" to each of the developed vacancy-chain indices, the same task was undertaken with regard to the Direction-of-Gain statistic. Here, after considering the measure in light of Lincoln's urban configuration, an arbitrary value of 2.6 was adopted to indicate the "significance" of the gain (term not as in statistics). Thus, chains with less than
2.6 miles of positive gain are considered "not significant" while those above 2.6 are "significant." Of course, the level of importance of the gain increases as the index for a chain increases above 2.6.

The statistics discussed in the preceding paragraphs are intended to assist in the spatial analysis of the vacancy chains, one of the central concerns of this work (see Chapter 1). Of course, other well-known, established quantitative techniques are also used in the geographic analysis of the intra-urban vacancy chains.

Indicators for Analyzing the Housing Environments of Residences in the Vacancy Chains

Because the vacancy chains for this project were not drawn from interviews but rather were gleaned from an existing data file, an analysis of the successive housing environments in a chain, necessary for a better understanding of the chaining process, is difficult. However, after scrutinizing the U.S. Census block-level data for housing, the author determined that a proper examination could be undertaken. Six "housing-environment indicators" were selected from the census data, four of which were used directly as presented in the census publication while two were devised by arithmetic manipulation of that published data. The four block-level indicators that were utilized as given include the: 1) owner average value of homes in the block; 2) average contract rent paid by renters in the block; 3) owner average number of rooms for homes in a block; and the 4) renter average number of rooms for units in each block. The two improvised indicators include the 5) percentage of total units in a block that are owner-occupied and the 6) percentage of total units in a block that are one-unit structures. These measures are considered by the author to be
indicative of the "housing environment" of individual blocks. From a comparison of these indicators as they relate to respective origins and destinations of individual moves in the vacancy chains, inferences as to whether or not movers have bettered themselves can be drawn and intra-chain, inter-chain, and inter-initiator-cell differences can be examined. Consequently, this approach focuses upon the characteristics of the "residential environment" of the block—as reflected in the six housing indicators—that each mover vacated and the one that he chose to enter.

**Objectives of Remaining Chapters**

The three remaining chapters each will be concerned with one of the central objectives of the study. Chapter 3 is a spatial analysis of the vacancy chains that were constructed from the Lincoln mobility data. This chapter, which provides the geographer with the first detailed maps of intra-urban vacancy chains for an American city, is the crux of the research. By referring to the maps, an attempt is made to qualitatively identify and describe a few characteristics of Lincoln's intra-urban system of migrant flow. The study also strives to quantitatively clarify the local patterns of movement in an effort to contribute to the body of knowledge concerning the spatial character of intra-urban migration. Finally, clustering procedures are utilized in an attempt to distinguish vacancy chains according to the six initiator cells of origin on the basis of the four indices discussed previously.

Chapter 4 is a housing-environment analysis of all the derived vacancy chains. Certain "housing-environment indicators," attached to
the various moves comprising the chains, are analyzed in order to assess the extent of residential filtering and also further elucidate the workings of intra-city vacancy chains. Clustering procedures are again utilized in an effort to group vacancy chains by the initiator cell of origin, but this time, only socio-economic variables are used.

Finally, Chapter 5 evaluates the utility of the concept of the vacancy chain in describing, analyzing, and explaining intra-urban mobility. This chapter includes the summarization of the vacancy-chain approach, an assessment of the developed methodologies, recommendations for future adjustments in the procedures, and suggestions for further research.
CHAPTER III

A SPATIAL ANALYSIS OF VACANCY CHAINS
LINCOLN, NEBRASKA, 1972

Introduction

The purpose of this chapter is to conduct a geographical analysis of the vacancy chains derived from the Lincoln mobility data. Information is provided on Lincoln's total mobility system in 1972, the ingressions to the six initiator cells, and "multipliers." The chapter also includes the maps of the Lincoln vacancy chains, which allow an inspection of the spatial manifestations of this intra-urban phenomenon. Some observations regarding the configurations of the chains within the city are made. Related to the description of the intra-urban moves is a section on the four "vacancy-chain indices." The real focus of this portion of the dissertation, however, is on the testing of certain hypotheses related to intra-urban migration, especially one concerning the statistical identification of "migratory streams."

Lincoln's Total Mobility System, 1972

The "Daily Moving Record" reported a total of 19,239 moves involving the city of Lincoln, Nebraska, during 1972. Of these, 12,779 (or 66.4%) were of the intra-urban variety. It seems phenomenal that such a large number of intra-urban household moves could take place in an urbanized area of 167,972 people in one year's time. If a minimum of 3 persons per household is used for calculating the percentage of
population turnover, however, we find that 22.8% of the populace was involved in a move within the confines of the urbanized area during 1972. Reference to the earlier discussion of mobility rates indicates that this figure is not out of line with other estimates of yearly urban population turnover (see Chapter 1). Lincoln, therefore, appears to be a suitable "laboratory" for this mobility study.

The monthly totals reflect the expected summer maximum, with the greatest number of residential changes (1,481) occurring in June (see Table 3-1, below). Oddly enough, though, July (with 1,010) was the only month in the May-September period that was below the 1972 monthly mean. This anomaly is not easily explained and it may be that the irregularity is merely a random deviation occurring through chance alone.

**TABLE 3-1**

TOTAL INTRA-URBAN MIGRATION INVOLVING LINCOLN IN 1972

<table>
<thead>
<tr>
<th>Month</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>920</td>
</tr>
<tr>
<td>February</td>
<td>859</td>
</tr>
<tr>
<td>March</td>
<td>1008</td>
</tr>
<tr>
<td>April</td>
<td>872</td>
</tr>
<tr>
<td>May</td>
<td>1174</td>
</tr>
<tr>
<td>June</td>
<td>1481</td>
</tr>
<tr>
<td>July</td>
<td>1010</td>
</tr>
<tr>
<td>August</td>
<td>1319</td>
</tr>
<tr>
<td>September</td>
<td>1197</td>
</tr>
<tr>
<td>October</td>
<td>978</td>
</tr>
<tr>
<td>November</td>
<td>1017</td>
</tr>
<tr>
<td>December</td>
<td>944</td>
</tr>
</tbody>
</table>

Sum = 12779
Mean = 1065
S.D. = 182
Ingressions to the Initiator Cells

During 1972, there were 789 total ingressions into the six initiator cells devised for this study, 580 (73.5%) of which were of the intra-urban variety. The greatest number of these ingressions (224) was to "College View," followed by 188 initial moves to "Meadowlane," 143 to "Wedgewood," 123 to "Bethany," 86 to "Trendwood," and 25 to "The Knolls." The differences in these numbers appear to reflect merely the unequal sizes and state of development in 1972 of the initiator cells.

The 789 ingressions to the six initiator cells yielded a total of 308 vacancy chains. There were, then, 481 "non-foundation ingressions," i.e., moves into one of the six initiator cells which did not result in vacancy chains. Of these 481 non-foundation ingressions, 162 could not possibly lead to a vacancy chain as there was no intra-urban vacancy left to allow a second link. This left 319 intra-urban

1In comparing this percentage (73.5) with the city of Lincoln as a whole, the author combined Lincoln's intra-urban migration and immigration, and concluded that 86.7% of the "city's ingressions" were of the intra-urban variety. Therefore, these peripheral areas (initiator cells) received a greater share of the new in-migrants than the other more central areas did.

2College View, Meadowlane, and Wedgewood are clearly the largest initiator cells (see Figure 2-2) in addition to being thoroughly built up by 1972. Bethany, Trendwood, and The Knolls are smaller cells with the latter two still experiencing a considerable amount of new construction in 1972.

3789-308=481.

4There were 45 moves from elsewhere in Nebraska, 92 from another state, 17 students moving home from University of Nebraska dormitories, etc., 3 from another country, and 5 from "Rural Route Lincoln" address, for a total of 162. Hence, a move from one of these locations into one of the initiator cells does not leave a vacancy elsewhere in the city, so there can be no second link, and, therefore, no vacancy chain (see "definitions," Appendix 'A').
moves to the initiator cells that could have resulted in vacancy chains but did not. Consequently, when an intra-urban ingressation into one of the initiator cells was examined in an attempt to link it with another move to form a chain, there was approximately a 50-50 chance of success.

Vacancy-Chain Totals

The 789 ingressions to the initiator cells yielded 308 vacancy chains consisting of 771 individual vectors or total links. If the

\[ 481 - 162 = 319 \]

There were two basic reasons for the inability of the author to create vacancy chains from these 319 intra-urban moves to the initiator cells. Firstly, the address (at the origin) of the move to the initiator cell simply was not in the computer list (see earlier discussion in Chapter 2). Thus, a second link could not be attached. This was, by far, the most prevalent reason for chains not being developed. If there was no record (in the computer list) of a move to fill the vacancy created by the move to an initiator cell, one had to assume that the dwelling-unit remained vacant for the remainder of 1972 since there was no way, given the nature of the data source, to account for occurrences such as a young person leaving the parental home to be married (See Chapter 2). It seems likely that some chains which began late in the year could have been continued if the data set had continued into 1973. The second (but not so prevalent) reason for the inability of the author to attach a second link to moves into one of the initiator cells is related to the problem of inconsistencies in the data (see earlier discussion in Chapter 2). If the initial move was from a multiple-unit structure and the exact apartment number could not be identified, no chain resulted.

In other words, 308 intra-urban ingressions became vacancy chains and 319 did not. For similar data conditions, one can expect to construct approximately 50 vacancy chains for every 100 ingressions examined when building sequences from an existing data set (as outlined in this thesis).

Though the total of 308 vacancy chains was somewhat disappointing to the author, it should be recognized that this is still a greater number of vacancy chains for one city than utilized in any of the previous studies. Frank S. Kristof, "Housing Policy Goals and the Turnover of Housing," Journal of the American Institute of Planners, Volume 31, August, 1965, pp. 232-245 based his results on 64 vacancy chains. J. B. Lansing, C. W. Clifton, and J. N. Morgan, New Homes and Poor People, Survey Research Center, University of Michigan, Ann Arbor, 1969, studied over 1,000 vacancy chains, but they were sampled from 17 S.M.S.A.'s (hence, average per city = approximately 60). Roman Dzus, "Residential Construction, Vacancy Chains, and Mobility Through Intra-
771 vectors of the finished vacancy chains are added to the 319 intra-urban non-foundation ingressions that were recorded and checked but could not be linked to other moves involving Lincoln, it can be seen that 1,090 total moves related to the six initiator cells were reviewed closely for this research.

In all, 688 of the 771 vectors were intra-urban in nature. Of course, the foundation moves are intra-urban by definition, but some of the other links were not, since some chains terminated by an intra- or inter-state move, which is still considered to be a chain "link" (refer to the "definitions," Appendix "A"). In terms of the vacancy chains, there were 246 that contained at least two intra-urban links. These are more important for some of the statistical measures utilized in this and the following chapter.

Multiplier Effect

The purpose of the "multiplier" is to assess the extent of housing turnover stimulated by the addition of new residential units (see earlier discussion, Chapter 1). Because this study focuses upon the spatial aspects of vacancy chains begun by intra-urban movement into initiator cells rather than a housing-market analysis based only


In addition, there were 98 third-link and 36 fourth-link (and later) intra-urban moves studied (308+246+98+36=688). By way of comparison, the 90 vacancy chains constructed by Dzus contained 55 second links, 21 third links, and 7 fourth links, while Romerill's 281 chains consisted of 171 second links, 43 third links, and 11 fourth links (see preceding footnote).
on new construction, the measure is of less interpretive value. It can, however, be utilized for comparative purposes.

In "multiplier terms," the 308 vacancy chains led to 771 total moves (in-migration included). Therefore, the "overall multiplier" is 2.50 (i.e., the average chain was 2.50 links in topological length). This finding compares favorably with the 1975 study done by Dzus who determined from his personal-interview data that the construction of 90 new dwellings in the city of Windsor, Ontario, led to 224 changes of residence (multiplier = 2.49). The "local multiplier," in-migration excluded, in Lincoln was found to be 2.23 (308 moves to the initiator cells led to 688 total intra-urban changes of residence). The local multiplier for Windsor was 2.22. By way of comparison, Romerill reported a rather low multiplier of 1.95 for Cincinnati, Kristof calculated a multiplier of approximately 2.40 for New York City, and Lansing and his colleagues computed a much higher multiplier of 3.5 in their national survey.

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9 Dzus, 1975, op. cit., p. 42.
10 Ibid.
11 Romerill, 1975, op. cit., p. 91; Kristof, 1965, op. cit., p. 241; and Lansing et al., 1969, op cit., p. 66. The discrepancies shown in the various multipliers reflect some of the difficulties in constructing vacancy chains. Lansing et al., in fact, state (pp. 65-66) that their result "... is subject to some margin of uncertainty ... " It must be remembered that the current work is the only one that did not utilize data from personal interviews. Because the Rundquist and Dzus multipliers are so similar, it appears that a proportionate number of chains ended by "interview failure" (Dzus) as ended by either reaching the end of the data set or not being able to complete a chain because of difficulties with multiple-unit structures (Rundquist). Romerill apparently had more difficulty in completing chains. From this, one could infer that the "Rundquist method" of building vacancy chains is at least as good as the techniques used by Kristof, Dzus, and Romerill. In a very strict sense, the true multiplier—i.e., the actual number of moves resulting from new construction
Spatial Manifestations of Intra-Urban Vacancy Chains

The 308 vacancy chains related to the six initiator cells were mapped for the purpose of undertaking the spatial analysis (Figures 3-1 through 3-6). In briefly discussing the maps, a "clockwise progression" will be used. In other words, the first initiator cell examined will be Bethany and the last will be The Knolls (refer to Figure 2-2). The same ordering of the initiator cells will be utilized in all tables contained in this and succeeding chapters.

Bethany

In 1972, 96 intra-city changes of residence terminated in Bethany, with 49 becoming foundation moves for vacancy chains. The 49 vacancy chains, comprising 111 individual intra-urban vectors, are presented as Figure 3-1. The pattern of the foundation moves, first of all, reflects a fairly heavy concentration of lines radiating from the southwest to the initiator cell and pointing toward an important rental area south of "O" Street, referred to as the "Near-South" neighborhood (in the state capitol area). A secondary group of vectors is oriented from the northwest toward the suburban cell, and these origin points appear clustered in the "University Place"--56th and Adams Streets--vicinity. The second-link vectors associated with Bethany reflect a predominant northeast-southwest orientation as evidence of some inter-

(Dzus, Romerill, Kristof, Lansing) or "foundation ingressions" (Rundquist)--cannot be determined for any of the studies. If this problem could be overcome, inter-city comparisons would be more meaningful.

12 The vectors are drawn from exact location of former residence to exact location of new residence, but extend only to the boundary of the initiator cell. Note that a variation in the line symbolization is used to distinguish between first, second, third, and fourth (or later) links.
Figure 3-1
action between the "Near-South" neighborhood and the "University Place" area. Notice, too, the movements between the 48th Street and Holdrege - 40th Street and Adams Street areas. Belmont (north-central Lincoln east of Highway 34) is also a part of the circulatory system begun in Bethany, as is Arnold Heights in far northwest Lincoln (west of the airport.)

Looking briefly at the spatial manifestations of the third-link vectors tied to initial moves into Bethany, one is struck by the great length of these moves, the preponderance of east-west trending vectors, and the interaction with Arnold Heights.

Meadowlane

During 1972, 143 intra-urban moves were made to Meadowlane with 81 becoming bona fide foundations for vacancy chains. The great number of vectors is perhaps the most notable feature of Figure 3-2, as 172 intra-urban changes of residence are mapped. The major concentration of the first-link or foundation vectors is the northeast-southwest trending group which originates south of "O" Street and the CBD in the older, rental-dominated, "Near-South" area. This concentration is even more apparent than in the previous figure. The preponderance of moves from the state-capitol or "Near-South" feeder area indicates the direct link between close-in rental areas of Lincoln and suburban Meadowlane. Other notable features of the first-link pattern as shown on this map include the secondary concentration of flows from

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13. The term "circulatory system" is used to refer to the flow pattern associated with an initiator cell (see Appendix "A").

14. Only one fourth-link was derived from the Bethany data, hence, there is no discussion.

15. A "feeder area" is a neighborhood from which migrants typically move.
Figure 3-2
Northeast Lincoln, the direct connection with Arnold Heights in far Northwest Lincoln, and the general lack of migrants to Meadowlane from other peripheral areas of the city. The second-link vectors related to initial moves into Meadowlane are more difficult to describe although there is some northeast-southwest interaction. There is intense movement within the "Near-South" neighborhood, itself, as evidenced by the many short, rather multi-directional vectors in that area. Arnold Heights was also part of this second-link system. The Meadowlane third-link vectors are similar to those for Bethany, though perhaps not as long and not as distinct in their orientation, while the fourth and later links for Meadowlane resemble the second links in terms of their spatial alignment.

**Wedgewood**

There were 106 intra-city ingressions into Wedgewood during 1972 resulting in 60 vacancy chains and 143 intra-urban vectors (Figure 3-3). The Wedgewood foundation moves bear a striking similarity to those for Meadowlane, though they do not appear to be as "concentrated." The direct connection with the state-capitol feeder area is still reflected as is that of University Place. The remainder of the pattern appears somewhat even with a fair amount of movement from areas southwest and northwest of the initiator cell. The second-link vectors for Wedgewood reflect a noticeable northeast-southwest trend. "intra-Near-South" interaction is again apparent, with some migration from "West Lincoln"—northeast of Capitol Beach Lake—to the 56th and Adams-Havelock Streets area. The Wedgewood third-link vectors are remarkably long and they manifest a decided northwest-southeast alignment, almost
Figure 3-3

VACANCY CHAINS TO WEDGEWOOD

KEY

- Link 1
- Link 2
- Link 3
- Link 4 (and later)

- STATE CAPITOL
- IN-MIGRANT
- MOVE WITHIN SAME APARTMENT BUILDINGS

0 1 2 3 MILE

Figure 3-3
at right angles to the preponderance of the second-link vectors. The fourth-and-later links for Wedgewood also seem rather long compared to those for other initiator cells.

**Trendwood**

Trendwood had 58 intra-urban ingressions during 1972 allowing the construction of 30 vacancy chains of 58 vectors (Figure 3-4). Despite the fact that this cell had relatively few ingressions, an unusual pattern surfaces here. While the overall spread of the foundation vectors appears fairly even, a northerly bias in direction is apparent. Many of the moves into this initiator cell came, then, from the other three "initiator neighborhoods" which lie to the north of Trendwood. None of the other initiator cells reflects a pattern quite like this. The vectors associated with Trendwood's second-link moves belie some alignment toward College View, while no distinct patterns are seen in the third and fourth-and-later links.

**College View**

There were 154 intra-urban ingressions into College View during 1972 leading to the construction of 73 vacancy chains totaling 165 intra-urban vectors (Figure 3-5). Three "clusters" of first-link vectors can be identified—one group of moves was almost straight south from the area around Wyuka Cemetery (40th and "O") into the peripheral cell; another oriented to the southeast toward the initiator cell but in most cases originating south of the more dense "Near-South" rental area; and a final group, also oriented to the southeast with most origins east of 27th and "A" Streets, between the two clusters just mentioned. Some initial movement from the other peripheral cells can
Figure 3-4
VACANCY CHAINS TO COLLEGE VIEW

KEY
- Link 1
- Link 2
- Link 3
- Link 4 (and later)

○ STATE CAPITOL
☆ IN-MIGRANT
△ MOVE WITHIN SAME APARTMENT BUILDING

Figure 3-5
also be noted. The second links consist of longer moves connecting the first-link origins with Northeast Lincoln and the "Near-South" area. The third- and fourth-link moves comprise a rather dense pattern of moves within the "Near-South" neighborhood itself. This latter "intra-Near-South" phenomenon is perhaps more clearly shown on this map than on any of the others.

The Knolls

As a result of the relatively small area outlined as the initiator neighborhood and the very low density of the housing in the area, only 24 intra-urban ingressions were recorded for The Knolls during 1972. From these, 15 vacancy chains with 44 intra-urban links were constructed (Figure 3-6). Though few in number, they do provide a glimpse into the circulation related to such a prestigious neighborhood. The foundation moves into The Knolls show a varied orientation, but several come from the "Lincoln Country Club" area south of Van Dorn near 17th Street. Others originate in Northeast Lincoln, and one even from Arnold Heights. The second-link moves related to The Knolls originate in several places, but Wedgewood and the College View area are apparently feeder cells. Other links are too few for any description.

Summary of Spatial Manifestations: Prospects for Multivariate Analysis

After viewing the spatial manifestations of the Lincoln vacancy chains, it became apparent that the great complexity of the maps hindered clear comprehension of the movement patterns. Some tentative statements can, however, be made by way of summarizing the mapped configurations and considering the possibilities for a statistical
VACANCY CHAINS TO THE KNOLLS

Figure 3-6
identification of "migratory streams."

In three of the six initiator cells—Bethany, Meadowlane, and Wedgewood—the most apparent initial flow seemed to be from the "Near-South" neighborhood. This central area tended to contribute directly to suburban expansion rather than a gradual, "zone-by-zone" type of movement (ala' Ernest Burgess). Perhaps this is a function of the size of Lincoln, with residents being equipped with more information about all parts of the city than would be the case in a much larger urban area. There are apparently some other distinct "migration tendencies" since the Link-1 moves to Trendwood, College View, and The Knolls were quite different from those of the three previously mentioned initiator cells, and each of these was slightly different. Trendwood, for example, appeared to be fed directly by some of the more northerly initiator cells in the city and other areas of Southeast Lincoln. College View, on the other hand, was tied directly to several areas, including a "farther south" neighborhood (see above for discussion of College View). The Knolls appeared to draw migrants mostly from the "Lincoln Country Club" area.

Regarding the second-link vectors, it seemed that the most prevalent tie was between the University-Place and "Near-South" neighborhoods. The maps indicated a rather continuous exchange between these two areas, excepting only chains associated with Trendwood and The Knolls. Second-link vectors tied to specific initiator cells also had other various neighborhoods as a part of their particular circulatory systems, such as Belmont for Bethany and West Lincoln for Wedgewood.

The third and fourth links appeared to be characterized by
east-west trending vectors—especially the Bethany and Meadowlane third links—and a rather concentrated "intra-Near-South" movement. It seems that by this stage in the vacancy chains, the movement tends to be of a very short distance, with little recognizable directional bias, and the moves are more "clustered" in the city. All of these notions are tested statistically in succeeding paragraphs.

The intra-urban movement as indicated by the Lincoln vacancy chains was found to be extremely complex. In some cases, inter-initiator-cell differences were apparent in the vacancy chains. Many repetitive configurations, though, were also seen. These spatial manifestations now need to be quantified to allow multivariate classification in order to confirm or deny the existence of the hypothesized "migratory streams."

Analysis

The maps of the vacancy chains (Figures 3-1 through 3-6) provide a view of the spatial patterns of intra-urban movement in Lincoln, Nebraska. Because of the spatial complexity of the sequences of moves, however, it was difficult to make generalizations regarding this intra-city phenomenon. Therefore, the maps were utilized primarily as a source of quantitative information needed for the investigations which follow.

Pertinent Hypotheses

Hypothesis 1: The majority of the moves comprising the vacancy chains traverse little physical distance with at least 60% being less than three miles in length.

This hypothesis is well founded in the literature concerning the spatial component called "distance." Simmons went so far as to
state that "... the most powerful regularity is the tendency to re-
locate near the origin." But the work of Butler, et al., based upon
a national survey, is most often cited with regard to migration dis-
tance. Butler and his colleagues concluded that 60% of all moves are
less than five miles in length. Many other academicians have also pro-
vided evidence for the empirical regularity that geographers term
"distance bias" or "distance decay." A 1969 study by Ronald Boyce,
however, led directly to the stated hypothesis when he found that the
average intra-urban move in Seattle was less than three miles.
Because Lincoln is much smaller than Seattle, at least 60% of the moves
should be less than three miles.

16 J. W. Simmons, "Changing Residence in the City: A Review of
Intra Urban Mobility," Geographical Review, Volume 58, Number 4,

17 E. W. Butler, et al., "Moving Behavior and Residential Choice:
A National Survey," National Cooperative Highway Research Report Number

18 See, for example, Richard L. Morrill and Forrest R. Pitts,
"Marriage, Migration, and the Mean Information Field: A Study of
Uniqueness and Generality," Annals, Association of American Geographers,
Volume 57, Number 2, June, 1967, pp. 401-422; Kevin R. Cox, Man,
Location, and Behavior: An Introduction to Human Geography, New York:
John Wiley and Sons, 1972, p. 19; R. J. Johnston, Spatial Structures,
New York: St. Martin's Press, 1973, p. 88; and Douglas Amedeo and
Reginald G. Golledge, An Introduction to Scientific Reasoning in
Geography, New York: John Wiley and Sons, 1975, p. 5.

19 Ronald Boyce, "Residential Mobility and Its Implications for
Urban Spatial Change," Proceedings, Association of American Geographers,
Volume 1, 1969, p. 23.
Hypothesis 2: The length of a link is inversely related to its position in the chain (with the first link being the longest).

This hypothesis is rooted in the work of Romerill who substantiated a similar hypothesis in Cincinnati in 1975 finding that "as chain length increased, the distance between units (or the movement distance of households) decreased." The maps of the Lincoln vacancy chains (Figures 3-1 through 3-6) also led the author to believe that the same phenomenon would surface in the move statistics for that smaller city.

Hypothesis 3: The statistical relationship between "directional bias" and link number decreases as the link number increases.

The stated hypothesis resulted largely from the work of W.A.V. Clark who has suggested (in what he termed an "inconclusive" study) that central-area changes of residence are somewhat random in nature while moves involving outer areas are more sectorally biased. Johnston provided further support for the stated hypothesis when he noted that "Although migrations of suburban households may generally be biased in terms of distance, direction, and sector, however, it is already clear that renters of central-city flats generally display only the first bias in their many moves."

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20 Romerill, 1975, op. cit., p. 152. Dzus, 1975, op. cit., p. 155, however, found "... no significant differences in mean length ..." of links in Windsor, a city roughly comparable to Lincoln in size.


vacancy chains also appeared to support the stated hypothesis. Therefore, it is expected that there will be a decreasing relationship between the two variables when Links 1 through 4 are considered individually.

Hypothesis 4: Vacancies in the sequences tend to "move" closer to the Central Business District.

Common sense regarding urban spatial structure and residential-movement processes would lead one to this hypothesis, but it is also founded in scholarly research, most notably the work of Lansing et al. Basing their findings upon (only) 61 vacancy chains that began in Detroit and remained in the city for at least one further position, the authors stated:

At position one, 6 percent of the dwellings are within ten miles of the center, 31 percent at position two, 50 percent at position three, 53 percent at position four, and 54 percent at positions five and above.

Lansing and his colleagues also found that the mean distances from the city center were 18.3 miles for position one, 14.6 for position two, 12.2 for position three, 11.9 for position four, and 12.8 miles for position five. This same tendency, for the vacancies to be located closer to the CBD as the position in the vacancy chain increases, should be apparent in the much-smaller city of Lincoln, Nebraska, provided the overall outward movement of migrants is the predominant

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23 Lansing et al., 1969, op. cit. See also Romerill, 1975, op. cit., p. 131.


25 Ibid., p. 119.
spatial process operating in the city.\textsuperscript{26}

Hypothesis 5: The degree of clustering of the link-origins varies with the position in the chain (with the Link-1 origins being the least clustered).

This hypothesis arose from reasoning concerning the previous hypothesis and urban spatial structure. If successive links in chains from all six initiator cells tend to become located closer to the CBD, it would also seem that the overall distribution of the move-origins would become more clustered. A pronounced clustering near the CBD for the final move-origin points in the sequences would imply that certain central-area neighborhoods do "benefit" (in the sense of freed housing) from new construction on or intra-urban moves to the urban periphery. In addition, if "migratory channels" do exist in the city, the geographical location of these "beneficiary areas" may vary according to the initiator cell in which the vacancy chain originated.\textsuperscript{27}

Hypothesis 6: Regular "migratory streams" are associated with each of the initiator cells and can be identified by "clustering" certain spatial characteristics related to the vacancy chains.

This statement is considered by the author to be the principal hypothesis of the dissertation since it is the problem to which the

\textsuperscript{26}Johnston, 1973, \textit{op. cit.}, p. 87, stated that this general outward movement of the people toward the urban periphery is indeed "... a major pattern in the distribution of migration directions within the city." The tie between the central "Near-South" neighborhood in Lincoln and the peripheral initiator cells (see earlier discussion) may affect the clarity of the hypothesized process, but the author expects the hypothesis to be substantiated.

\textsuperscript{27}A "beneficiary area" is the neighborhood in a city that eventually benefits in terms of freed housing, either from new construction of residences on the urban periphery or out-migration from these more peripheral locations.
work is addressed (see Chapter 1). Several scholarly works have implied that intra-urban migration is "channelized" but none has substantiated this claim. If the stated hypothesis is validated, it could have positive ramifications for planners. For example, if migratory streams do exist and they can be identified, then the location of new construction can be more effectively planned in order to supplement the supply of housing in certain areas of the city.

Spatial Components

Distance

There are two basic spatial aspects to any intra-urban change of residence--distance and direction. The most fundamental and well-documented concept intrinsic to all forms of residential mobility is distance, and characteristics related to that spatial component are treated in this section.

Hypothesis 1: The majority of the moves comprising the vacancy chains will traverse little physical distance with at least 60% being less than three miles in length.

The most expeditious means of testing this hypothesis is to simply place each move-distance into a tabular format with specified distance groupings. Table 3-2 is the synopsis of the moves as analyzed in this fashion with Part A containing the absolute number of occurrences in each category and Part B the percentages.

With regard to the Link-1 figures for each initiator cell, notice

### Table 3-2

**DISTRIBUTION OF DISTANCES: ONE-MILE GROUPINGS**

**Part A: Absolute Number of Occurrences**

<table>
<thead>
<tr>
<th>Distance Category</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1 L2 L3 L4</td>
<td>L1 L2 L3 L4</td>
<td>L1 L2 L3 L4</td>
<td>L1 L2 L3 L4</td>
<td>L1 L2 L3 L4</td>
<td>L1 L2 L3 L4</td>
<td></td>
</tr>
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<td>&lt; 1 mile</td>
<td>9 16 4 0</td>
<td>9 22 11 3</td>
<td>2 15 6 3</td>
<td>3 6 3 4</td>
<td>8 17 10 2</td>
<td>3 4 0 -</td>
<td>34 30</td>
</tr>
<tr>
<td>1 - 1.99</td>
<td>18 12 3 0</td>
<td>14 17 3 3</td>
<td>9 15 4 2</td>
<td>7 3 3 1</td>
<td>17 13 7 4</td>
<td>6 4 1 -</td>
<td>71 64</td>
</tr>
<tr>
<td>2 - 2.99</td>
<td>5 4 3 0</td>
<td>14 11 7 4</td>
<td>15 9 6 4</td>
<td>8 5 1 0</td>
<td>12 12 4 0</td>
<td>1 2 0 -</td>
<td>55 43</td>
</tr>
<tr>
<td>3 - 3.99</td>
<td>5 7 1 1</td>
<td>18 8 0 2</td>
<td>21 3 4 1</td>
<td>6 2 0 0</td>
<td>23 8 4 0</td>
<td>0 1 0 -</td>
<td>73 29</td>
</tr>
<tr>
<td>4 - 4.99</td>
<td>7 4 4 0</td>
<td>15 3 1 0</td>
<td>9 7 1 1</td>
<td>5 0 1 0</td>
<td>9 6 0 0</td>
<td>1 0 1 -</td>
<td>46 20</td>
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<td>2 1 0 0</td>
<td>5 1 0 0</td>
<td>3 1 0 0</td>
<td>0 1 0 0</td>
<td>1 2 0 0</td>
<td>1 1 0 -</td>
<td>12 7 0</td>
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<td>0 0 0 0</td>
<td>0 0 1 0</td>
<td>1 0 0 0</td>
<td>1 0 1 1</td>
<td>2 0 0 -</td>
<td>4 0 2 1</td>
</tr>
<tr>
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<td>0 0 1 0</td>
<td>0 0 0 0</td>
<td>0 0 0 0</td>
<td>0 0 0 0</td>
<td>1 0 0 0</td>
<td>0 0 0 -</td>
<td>1 0 1 0</td>
</tr>
<tr>
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<td>1 1 1 0</td>
<td>0 0 0 0</td>
<td>0 0 0 0</td>
<td>0 1 0 0</td>
<td>0 0 0 -</td>
<td>2 2 2 0</td>
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<tr>
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<td>2 0 0 0</td>
<td>5 0 0 0</td>
<td>1 0 0 0</td>
<td>0 1 0 0</td>
<td>1 0 0 0</td>
<td>1 0 0 -</td>
<td>10 1 0 0</td>
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<tr>
<td><strong>Total</strong></td>
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<td>81 63 23 12</td>
<td>60 50 22 11</td>
<td>30 18 8 5</td>
<td>73 59 26 7</td>
<td>15 12 2 -</td>
<td>308 246 98 36</td>
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<td>Bethany Meadowline</td>
<td>Wedgewood</td>
<td>Trendwood</td>
<td>College View</td>
<td>The Knolls</td>
<td>Total</td>
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<td>-------</td>
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</tr>
<tr>
<td>&lt; 1 mile</td>
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<td>0 11.1 34.9 47.8 25.0</td>
<td>3.3 30.0 27.3 27.3</td>
<td>10.0 33.3 37.5 80.0</td>
<td>11.0 28.8 38.5 28.6</td>
<td>11.0 11.0</td>
<td></td>
</tr>
<tr>
<td>1 - 1.99</td>
<td>36.7 27.3 17.7</td>
<td>0 17.3 27.0 13.0 25.0</td>
<td>15.0 30.0 18.2 18.2</td>
<td>23.3 16.7 37.5 20.0</td>
<td>23.3 22.0 26.9 57.1</td>
<td>40.0 33.3</td>
<td></td>
</tr>
<tr>
<td>2 - 2.99</td>
<td>10.2 9.1 17.7</td>
<td>0 17.3 17.5 30.4 33.3</td>
<td>25.0 18.0 27.3 36.4</td>
<td>26.7 27.8 12.5</td>
<td>0 16.4 20.3 15.4</td>
<td>0 6.7 16.7</td>
<td></td>
</tr>
<tr>
<td>3 - 3.99</td>
<td>10.2 15.9 5.9 100.0</td>
<td>22.2 12.7</td>
<td>0 16.7 35.0</td>
<td>6.0 18.2 9.1</td>
<td>20.0 11.1</td>
<td>0 0 31.5 13.6 15.4</td>
<td>0 0 8.3</td>
</tr>
<tr>
<td>4 - 4.99</td>
<td>14.3 9.1 23.5</td>
<td>0 18.5 4.8 4.4</td>
<td>0 15.0 14.0</td>
<td>4.6 9.1</td>
<td>16.7</td>
<td>0 12.5</td>
<td>0 12.3 10.2</td>
</tr>
<tr>
<td>5 - 5.99</td>
<td>4.1 2.3 0</td>
<td>0 6.2 1.6</td>
<td>0 0 5.0 2.0</td>
<td>0 0</td>
<td>0 5.6</td>
<td>0</td>
<td>0 1.4 3.4</td>
</tr>
<tr>
<td>6 - 6.99</td>
<td>0 0 0 0</td>
<td>0 0 0 0</td>
<td>0 0 4.6</td>
<td>0 3.3</td>
<td>0 0</td>
<td>0 1.4</td>
<td>0 3.8</td>
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<tr>
<td>7 - 7.99</td>
<td>0 0 5.9</td>
<td>0 0 0 0</td>
<td>0 0 0</td>
<td>0 0</td>
<td>0 0</td>
<td>0 1.4</td>
<td>0 0</td>
</tr>
<tr>
<td>8 - 8.99</td>
<td>2.0 0 5.9</td>
<td>0 1.2 1.6 4.4</td>
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<td>9 - 9.99</td>
<td>4.1 0 0</td>
<td>0 6.2</td>
<td>0 0 1.7</td>
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<td>0</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99.9 99.9 99.9</strong></td>
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<td><strong>0 0</strong></td>
<td><strong>0 0</strong></td>
<td><strong>0 0</strong></td>
</tr>
</tbody>
</table>
that in all cases, the greatest percentage of moves is in a "distance ring" other than the shortest—the "less-than-one-mile" category (Part B of Table 3-2). The "Total" column for Link 1 points out the fact that only 11% of all Link-1 moves were less than one mile in length (refer to right-hand column of Part B of the table). The bulk of the Link-1 moves—in fact, 64.7%—are between 1 and 3.99 miles and a full 79.6% are between 1 and 4.99 miles. Notice, too, that the highest percentages for the Link-2 moves are always—except in the case of The Knolls—in the "less-than-one-mile" category. The "Total" column in Part B of the table shows that 32.5% of the Link-2 moves are less than one mile in length, 58.5% are 1.99 miles or less, and a full 76% are 2.99 miles or less in physical distance. The total percentages for Link 3 are similar to those for Link 2 with 34.7% of all the Link-3 moves being less than one mile long and 77.5% being 2.99 miles or less in length. The Link-4 statistics again follow the trends of Links 2 and 3 with 33.3% of the moves for Link 4 being less than one mile long and 83.3% less than 2.99 miles in distance.

As was stated in Chapter 1 (section on "mobility generalizations"), the previous literature on intra-urban residential mobility has shown time and again that most moves are very short in terms of physical distance. This general finding and the specific work of Boyce led to the hypothesis being tested here that the majority of the intra-urban moves in Lincoln during 1972 will cover little distance and 60% will cover less than three miles.\(^\text{29}\) The hypothesis was accepted since 65.9% of all the 688 intra-urban changes of residence examined in Lincoln were less than 2.99 miles in length. In order to test the

\(^{29}\) Boyce, 1969, *op. cit.*
probability of obtaining the result by chance, the figures were subjected to a "Single-Sample Test for Individual Proportions." The formula is:

\[ z = \frac{P_o - P_h}{\sqrt{P_h Q / N}} \]

Where:  
- \( z \) = the \( z \)-statistic  
- \( P_o \) = the observed proportion (65.9% in this case)  
- \( P_h \) = the hypothesized proportion (60%)  
- \( Q \) = the hypothesized alternative (40%)  
- \( N \) = the number of cases (688)

A \( z \)-statistic of 3.15, significant at a level of .0008, indicated that it was highly improbable that the finding occurred through chance alone.

The complete results with regard to the proportions within the distance categories is as follows: 23.3% were less than 1 mile, 47.4% were less than 1.99 miles, 65.9% were 2.99 miles or less, 82.6% were less than 3.99 miles, and 93.5% were less than 4.99 miles.\(^{30}\)

**Hypothesis 2:** The length of a link is inversely related to its position in the chain (with the first links being the longest).

A comparison of the average distance of moves according to the link-position in the chain is a second way to analyze this spatial component of migration. Part A of Table 3-3 is a synopsis of the mean

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\(^{30}\)In reference to Lincoln's size, it is about 7.7 miles from Capitol Beach Lake to 84th Street along "O" and 7.1 miles from Superior Street to Old Cheney Road along 40th (See Figure 2-2). From the Peak Land Value Intersection, at 14th and "O" Streets, to 84th and "O," it is about 5.1 miles. From Arnold Heights in far Northwest Lincoln to 84th and "O," it is approximately 10 miles.
distance for each initiator cell by link-group, and Part B lists all standard deviations, coefficients of variation, and "n" sizes.

The first notable feature of Table 3-3, Part A, is the contrast between initiator cells in terms of mean link-distances. For example, notice the perfect pattern reflected in the case of Trendwood where mean distances become shorter as the "generation" of the move increases, i.e., Link 1 is typically the longest and Link 4 the shortest. While the figures for Trendwood are so "ordered," variation is evident in the links associated with the other initiator cells. Although the link-group means for Meadowlane, Wedgewood, and College View nearly comprise an ordered progression similar to that for Trendwood, Bethany is the reverse—as the link number beyond Link 2 increases, so do the distances. The "Link-4 group mean" for Bethany can be explained by an "n-size" of only one observation (see Part B of Table 3-3); but the high "Link-3 average" for the same initiator cell is perhaps explained by the interaction with Arnold Heights (see Figure 3-1). Though the number of cases is low for links associated with The Knolls, the averages are relatively high.

The standard deviations for each link-group for the six peripheral initiator cells range from a very "constant"—e.g., Wedgewood—through a "somewhat regular" declining progression with increasing position away from the initial moves—e.g., Meadowlane—to "erratic"—e.g., Bethany, Trendwood, and The Knolls (Part B of Table 3-3). In the case of moves related to the latter three neighborhoods, the link-groups do not appear to have an effect on the variation about the mean value of the distances of individual moves.

The averages of the link-group means show a lengthy 3.0 mile
TABLE 3-3
DISTANCE CHARACTERISTICS OF INTRA-URBAN LINKS
(Values in Miles)

**Part A: Mean Distance**

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.7</td>
<td>3.4</td>
<td>3.2</td>
<td>2.7</td>
<td>2.8</td>
<td>3.2</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>1.9</td>
<td>1.9</td>
<td>2.0</td>
<td>2.3</td>
<td>2.2</td>
<td>1.9</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>3.1</td>
<td>1.7</td>
<td>2.3</td>
<td>1.5</td>
<td>1.7</td>
<td>3.0</td>
<td>2.1</td>
</tr>
<tr>
<td>4+</td>
<td>3.6</td>
<td>2.1</td>
<td>1.9</td>
<td>0.6</td>
<td>2.0</td>
<td>-</td>
<td>1.8</td>
</tr>
</tbody>
</table>

**Part B: Standard Deviations, Coefficients of Variation, and Number of Cases**

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Totals (Weighted Means)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>CV</td>
<td>N</td>
<td>S</td>
<td>CV</td>
<td>N</td>
<td>S</td>
<td>CV</td>
</tr>
<tr>
<td>1</td>
<td>2.2</td>
<td>.80</td>
<td>49</td>
<td>2.2</td>
<td>.65</td>
<td>81</td>
<td>1.4</td>
</tr>
<tr>
<td>2</td>
<td>1.4</td>
<td>.74</td>
<td>44</td>
<td>1.6</td>
<td>.83</td>
<td>63</td>
<td>1.5</td>
</tr>
<tr>
<td>3</td>
<td>2.3</td>
<td>.75</td>
<td>17</td>
<td>1.8</td>
<td>1.10</td>
<td>23</td>
<td>1.4</td>
</tr>
<tr>
<td>4+</td>
<td>0.0</td>
<td>0.0</td>
<td>1</td>
<td>1.1</td>
<td>.51</td>
<td>12</td>
<td>1.2</td>
</tr>
<tr>
<td>Total</td>
<td>111</td>
<td>179</td>
<td>143</td>
<td>61</td>
<td>165</td>
<td>29</td>
<td>688</td>
</tr>
</tbody>
</table>
average for all foundation moves (refer to the right-hand column of Part A of Table 3-3) while the average values for the other three link-groups all are near 2 miles. Most importantly, then, it can be seen that the initial moves are, on the average, about one mile longer than Links 2, 3, and 4, which remain very similar. On the whole, there is very little difference in distance among the lengths of the second, third, and fourth links, but all three differ from the first link. In order to determine the statistical significance of the differences between the mean values for the successive pairs of link-groups, they were subjected to a "T-Test for Independent Samples." The formulation is:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(n_1 - 1) s_1^2 + (n_2 - 1) s_2^2}{n_1 + n_2 - 2} \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where: $t =$ the t-statistic
$\bar{x}_1 =$ the mean for the first sample
$s_1^2 =$ the variance of the first sample
$n_1 =$ the number of cases in the first sample

The calculated "t" value for the difference between the Link-1 and Link-2 average distances was 6.53 (with 552 degrees of freedom), significant beyond the .005 level. "t" for the Link-2 and Link-3 means was -2.43 (with 342 degrees of freedom), significant beyond the .01 level. Finally, a "t" value of 0.77 (with 132 degrees of freedom) indicated that the difference between the Link-3 and Link-4 means was not statistically significant.
The findings summarized in Table 3-3 and the "t" tests allow a decision regarding the stated hypothesis: "The length of a link is inversely related to its position in the chain (with the first links being the longest)." The movers in the first position of the Lincoln vacancy chains did traverse the greatest distance, those comprising the second links averaged one mile less, and the mean for the fourth-link moves was the shortest. Thus, the relationship tended to be inverse. At the same time, a statistically significant difference was found between Links 1 and 2 and between Links 2 and 3.31 Although there was some evidence to the contrary (e.g., the slightly higher average distance for Link 3 and the non-significant "t" between Links 3 and 4), the hypothesis was accepted.

Direction

Directional bias, the second spatial component of an intra-urban change of residence, is not well understood and lacks sound empirical verification (see earlier discussion in Chapter 1). In an attempt to contribute to the small body of knowledge concerning this spatial characteristic, the following hypothesis was tested:

Hypothesis 3: The statistical relationship between "directional bias" and link number decreases as link number increases.

The actual measurement of the direction of the residential changes was accomplished by attaching a "back azimuth" to each of the moves. For example, if the azimuth of an origin-to-destination vector were 90 degrees (measured from grid north), the back azimuth would

---

31 The probabilities for "t" also decrease as link-numbers increase (.005 for Links 1-2, .01 for Links 2-3, and "not significant" for Links 3-4).
simply to 270 degrees (180 + 90 = 270). All azimuths were converted to back azimuths to "standardize" the destinations, i.e., normalize them in the sense of placing all destinations in one location. Thus, all destinations for each link-group were considered to be a single point with back azimuths converging on that point.

The back azimuths for each move in a vacancy chain were measured and classified into one of twelve categories, each 30 degrees wide (see diagram below). Each link-group was then subjected to Chi-Square analysis to test the relationship between the link number and the frequency of occurrence in the directional categories. Chi-Square for the Link-1 back azimuths was 130.17 with 5 degrees of freedom
The value for Link 2 was 10.77, that for Link 3 was 8.30, and Link 4 was 8.68 (all of which were not statistically significant). Despite the fact that \( X^2 \) for Link 4 was slightly higher than for Link 3, the relationship between link number and directional bias does tend to be inverse. Because the relationship generally lessens as link number increases, indicating that central-area moves are more random in nature than those for outer areas, the hypothesis was accepted.

Other Spatial Tendencies

As discussed in Chapter 1, one of the advantages of using the vacancy-chain approach for the study of intra-urban migration is the fact that the original individual-level data can be aggregated gradually to provide a view of this spatial phenomenon at more than one "level." The analyses in the current chapter have included the "micro-studies" of distance and direction where each move was considered individually, and the linked moves (vacancy chains) described by the

Because the six initiator cells were located on the periphery of the city, the generation of the expected distribution for Link 1 was made difficult (since half of the "directional wedges" were not likely to receive a move). To overcome this problem, the 0°-to-180° portion of the model was omitted for Link 1. Since the College-View and Knolls initiator cells are on the southern margin of the city, the model was rotated 90° clockwise for these latter two initiator neighborhoods. Therefore, there were 5 degrees of freedom for the Link-1 contingency table.

When all twelve directional categories were used, the original figure for Link 4 was 25.98. But because of the low number of cases (36), many of the categories had values of less than 5, which tends to invalidate the Chi-Square statistic. Therefore, the categories for the Link-4 moves were widened to 60° resulting in 6 groups (and 5 degrees of freedom). This combination of categories resulted in a truer representation of the distribution of back azimuths for that link-group.
This section of the chapter is aimed at providing an even more comprehensive view of the vacancy chains that were mapped within Lincoln as the chains will be viewed in terms of certain summary statistics.

Hypothesis 4: Vacancies in the sequences tend to "move" closer to the Central Business District.

The line-symbol maps of the vacancy chains, shown as Figures 3-1 through 3-6, were clarified by converting the data to point symbols. The resulting Figures 3-7 through 3-10, which depict only the individual vector origins, can be assessed briefly and qualitatively with respect to the stated hypothesis.

Many of the same patterns described with regard to the maps of vacancy chains are again reflected in Figures 3-7 through 3-10. Most importantly, though, notice that beginning with the Link-2 origins (Figure 3-8), there appears to be an increasing tendency for points to be concentrated near the CBD with a relative lessening in outer areas. On a qualitative basis, the stated hypothesis seems acceptable, but further testing is in order.

A simple but effective way to both test the hypothesis and provide more insight into the intra-urban migration process as it operates within the city of Lincoln is to make use of certain summary statistics. One centrographic measure which was of some use in this work is "Mean Center." Thus, the vector origins shown in Figures 3-7 through 3-10 were assigned cartesian coordinates and simplified to "average locations." Through the use of this descriptive statistic, one location was derived which stands for each of the link-group vector origins, e.g., one measure of central tendency was calculated for the Link-1 origins for Wedgewood, one for the Link-2 origins for Wedgewood, and
VECTOR ORIGINS: SECOND LINKS

KEY
- Bethany (B)
- Meadowlone (M)
- Wedgewood (W)
- Trendwood (T)
- College View (C)
- The Knolls (K)
- STATE CAPITOL.

Figure 3-8
VECTOR ORIGINS: FOURTH (AND LATER) LINKS

KEY
- Bethany (B)
- Meadowlone (M)
- Wedgewood (W)
- Trendwood (T)
- College View (C)
- The Knolls (K)
- STATE CAPITOL

HILAND AVE.

VECTJR ORIGINS: FOURTH AND LATER LINKS

Figure 3-10
so on. The same was done for all links and the other five initiator cells.

The Mean Centers for each link-group and initiator cell reveal a general tendency for vacancies to "move" closer to the CBD (Figure 3-11). The mean points for Bethany, Wedgewood, and Trendwood provide evidence in support of the stated hypothesis. The College-View vector origins display the same tendency despite the mean for Link 4 being farther from the center of the city than the Link-3 mean. While the Mean Centers for Meadowlane are extremely close together—less than one-half mile apart—only the Link-4 mean is anomalous to the general pattern. The Mean Centers for link origins associated with The Knolls, however, are reversed from the "norm" as the Link-1 mean is closest to the Peak Land Value Intersection, followed in order by Links 2 and 3. The differences in distance from the PLVI are slight, though, and the Mean Centers for The Knolls appear, on the map, to parallel the CBD.

Because the number of cases for The Knolls is low and since the other initiator cells tend to reflect a similar pattern in terms of the Mean Centers of their vector origins, the hypothesis that "vacancies in the sequences tend to 'move' closer to the central Business District" was accepted.

If the Mean Centers are connected to form "average vacancy chains" tied to each of the six peripheral initiator cells, some additional observations can be made (see Figure 3-11). The great length of the foundation moves as compared to the other links is again clearly seen on the map. The lack of sizable differences in the lengths of the second, third, and fourth links is also apparent. When the mean-vector origins are connected together as done here, they reflect some
MEAN CENTERS OF VECTOR ORIGINS

NOTE: NUMBERS REPRESENT MEAN ORIGINS OF LINK-GROUPS FOR EACH INITIATOR CELL.

Figure 3-11
spatial differences, although the later link-origins do seem to gravitate to one general area of the city.\textsuperscript{34} In addition, the chains for Bethany and Meadowlane are entirely north of "O" Street while the chains for the other initiator cells are entirely south of "O" Street. On the average, then, chains that begin in neighborhoods north of "O" Street will also end north of that main thoroughfare, and vice-versa. Could this be indicative of two "separate" housing markets, one in "North Lincoln" and one in "South Lincoln?" The map would seem to indicate that new construction south of "O" Street would do little in terms of creating eventual vacancies in the low-income areas in Lincoln such as "Malone" and "Clinton," both of which are north of "O" Street.\textsuperscript{35} Finally, the map shown as Figure 3-11, although the result of a very simplistic technique, is one of the few--and may be the only--empirical spatial models of intra-urban movement shown for any city. It clearly shows that, on the average, migration flows are away from the CBD.

Hypothesis 5: The degree of clustering of the link-origins varies with the position in the chain (with the Link-1 origins being the least clustered).

All cartesian coordinates for the individual vector origins utilized in the determination of the Mean Centers (see above) were further aggregated into four groups--all Link-1 origins, Link-2 origins, Link-3 origins, and Link-4 origins.\textsuperscript{34} The author realizes that the areal mean is only a summary statistic dealing with central tendencies, and that there are many spatial situations that could produce the same summary positions. Therefore, the discussion in this paragraph dealing with housing markets is only speculation on the part of the writer.

\textsuperscript{35}Dzus, 1975, op. cit., p. 105, reported the existence of two major housing submarkets in Windsor.
Link-3 origins, and Link-4 (and later) origins. These point locations were then subjected to "Nearest-Neighbor Analysis" for the purpose of testing the stated hypothesis.

Table 3–4 contains the results of the analysis of the point distributions related to each of the link-groups. The smallest deviation for the Link-1 vector origins (0.0987) was from randomness, and therefore, the distribution had to be classified as random. Surprisingly (in view of the stated hypothesis), the Link-2 deviation from randomness was even smaller (0.0643) implying a random distribution for this link-group. In addition, the smallest deviations for the Link-3 and Link-4 vector origins were also from randomness.

If one refers to the "clustered deviations," it is interesting to note that the deviation increases as link number increases, i.e., the Link-1 distribution is closest to clustered and that for Link-4 is furthest from clustered. This is the complete reverse of what was expected (see hypothesis). Therefore, the Hypothesis was rejected.

TABLE 3–4
NEAREST-NEIGHBOR ANALYSIS:
TOTAL DEVIATIONS

<table>
<thead>
<tr>
<th>Link</th>
<th>Total Randomness Index</th>
<th>Uniformity Deviation</th>
<th>Randomness Deviation</th>
<th>Clustered Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link 1</td>
<td>1.1333</td>
<td>0.2518</td>
<td>0.0987</td>
<td>0.6000</td>
</tr>
<tr>
<td>Link 2</td>
<td>1.0666</td>
<td>0.3019</td>
<td>0.0643</td>
<td>0.6442</td>
</tr>
<tr>
<td>Link 3</td>
<td>1.1089</td>
<td>0.4236</td>
<td>0.1341</td>
<td>1.1675</td>
</tr>
<tr>
<td>Link 4+</td>
<td>1.2432</td>
<td>0.6972</td>
<td>0.5024</td>
<td>2.3328</td>
</tr>
</tbody>
</table>
Despite the fact that visual inspection of Figures 3-7 through 3-10 would cause one to infer that the degree of clustering of the points near the central city increases as link number increases, there are numerous other points scattered throughout the city. These other vector origins, along with a decreasing number of cases with each link-group, apparently caused the rejection of the hypothesis. In other words, the nature of the Nearest-Neighbor statistic, itself, may be a factor in the obtained result. At the same time, though, recall that the Chi-Square analysis revealed a general inverse relationship between link number and directional bias. Since the orientation of the moves near the central city is more "random" than those further out, the result appears to be an increasingly "lower level" of clustering of the move origins. In other words, as link number increases, the locations of the move-origins vary to a greater extent (with respect to one another).

The Search for "Migratory Streams"

As was stated in Chapter 1, this study emphasizes the spatial manifestations and geometric character of vacancy chains in describing, analyzing, and explaining the patterns of intra-city residential movement. The crux of the research, though, involves the use of the vacancy chains to either confirm or deny the existence of intra-urban "channels of migration."
Hypothesis 6: Regular "migratory streams" are associated with each of the initiator cells and can be identified by "clustering" certain spatial characteristics related to the vacancy chains.

Since maps alone do not constitute sufficient grounds for either accepting or rejecting the stated hypothesis, it became necessary to make use of certain quantitative derivatives of the maps (the "spatial characteristics" mentioned in the hypothesis). Four statistics, "Spacing," "Sinuosity," "Azimuth Differential," and "Direction of Gain" (see Chapter 2) form the basis for the search for migratory streams since the hypothesis rests on the notion that chains originating in the six peripheral initiator cells can be grouped in four-dimensional space on the basis of the "scores" for the four indices. While the importance of these indices lies in the test of their ability to be clustered, a brief description of the findings relative to each measure follows below.

**Chain Spacing**

The "Spacing Index" provides a measurement of the actual spacing between residences in a particular chain. Recall from Chapter 2 that a high index means that there were great differences in the actual physical distances of links in a particular chain, and a low index shows regularity in the distances traveled.

Spacing Indices were calculated for all 246 vacancy chains that contained at least two intra-urban links. The number of occurrences in each "index-group" is classified according to initiator cell (Table 3-5). The statistics shown as percentages refer to the total number of vacancy chains in each initiator cell found in each "index category."
A minimum of one-half of the chains begun in Bethany, Wedgewood, and College View have indices of .99 or less—indicative of at least fairly regular spacing. Chains originating in Trendwood and The Knolls do not exactly fit the pattern of the three initiator cells just noted, but the smaller number of cases for these two cells may have influenced the results. The Meadowlane chains are a bit unusual, with rather high percentages in those categories showing irregular spacing—30.2% in the 1.00-2.24 range and 15.9% in the 2.25-3.99 category. Interaction with Arnold Heights surely contributed to these higher-than-average statistics (refer back to Figure 3-2). As a whole, though, the table points up the fact that 48.4% of all the chains have Spacing Indices of .99 or less—with a fairly even breakdown in the three lowest categories.

The higher values for Meadowlane are also reflected in Table 3-6 which simply lists the mean indices for all chains associated with each of the initiator cells. Note that the average values range from a high of 3.00 for Meadowlane down to 1.40 for College View. Notice, too, that while almost half of the chains have low Spacing Indices, the standard deviations are, in all cases, larger than the mean for the initiator cell and the coefficients of variation are larger than one—all indicative of substantial fluctuation about the mean.

36 It was decided by the author that those indices that were below .25 would be termed "regular," those between .25 and .99 "fairly regular," and those 1.00 or above "not regular" (see Chapter 2).

37 The reader may recall from the map of Mean Centers that there was little difference in the positions of the four mean points for Meadowlane (see Figure 3-11).

38 The table is based on the original interval data.
### TABLE 3-5

**SUMMARY OF ALL SPACING INDICES**

<table>
<thead>
<tr>
<th>Sp</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>&lt; .25</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>3</td>
<td>21</td>
<td>4</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>25.0</td>
<td>14.3</td>
<td>22.0</td>
<td>16.7</td>
<td>35.6</td>
<td>33.3</td>
<td></td>
</tr>
<tr>
<td>.25 - .99</td>
<td>11</td>
<td>25.0</td>
<td>14</td>
<td>22.2</td>
<td>15</td>
<td>22.2</td>
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<td>30.0</td>
<td>30.0</td>
<td>22.0</td>
<td>1</td>
<td>8.3</td>
<td>60</td>
</tr>
<tr>
<td>1.00 - 2.24</td>
<td>8</td>
<td>18.2</td>
<td>19</td>
<td>30.2</td>
<td>5</td>
<td>27.8</td>
<td>1.00</td>
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<tr>
<td>2.25 - 3.99</td>
<td>8</td>
<td>18.2</td>
<td>10</td>
<td>15.9</td>
<td>4</td>
<td>8.0</td>
<td>3</td>
</tr>
<tr>
<td>3.00 - 4.99</td>
<td>3</td>
<td>6.8</td>
<td>5</td>
<td>7.9</td>
<td>3</td>
<td>6.0</td>
<td>2.00</td>
</tr>
<tr>
<td>4.00 - 6.24</td>
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<td>0</td>
<td>1</td>
<td>2.0</td>
<td>0</td>
<td>0</td>
</tr>
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<td>6.25 - 8.99</td>
<td>2</td>
<td>4.5</td>
<td>2</td>
<td>3.2</td>
<td>0</td>
<td>0</td>
<td>1.00</td>
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<td>9.00 - 12.24</td>
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<td>1</td>
<td>5.6</td>
<td>1.7</td>
</tr>
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<td>12.25 - 15.99</td>
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<td>2.0</td>
<td>1</td>
<td>5.6</td>
<td>1</td>
</tr>
<tr>
<td>16.00 - 20.24</td>
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<td>0</td>
<td>2</td>
<td>3.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20.25 - 30.24</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
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<td>100.0</td>
<td>63</td>
<td>100.1</td>
<td>50</td>
<td>100.0</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
<td>100.1</td>
<td>50</td>
<td>100.0</td>
<td>18</td>
<td>100.1</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
<td>100.0</td>
<td>12</td>
<td>99.8</td>
<td>246</td>
<td>99.9</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>24.0</td>
<td>14.2</td>
<td>33.3</td>
<td>14.2</td>
<td>61</td>
<td>24.8</td>
<td>24.4</td>
</tr>
</tbody>
</table>
TABLE 3-6
MEANS, STANDARD DEVIATIONS, AND COEFFICIENTS
OF VARIATION OF SPACING INDICES

<table>
<thead>
<tr>
<th>Initiator Cell</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bethany</td>
<td>2.20</td>
<td>3.15</td>
<td>1.44</td>
</tr>
<tr>
<td>Meadowlane</td>
<td>3.00</td>
<td>4.62</td>
<td>1.54</td>
</tr>
<tr>
<td>Wedgewood</td>
<td>1.62</td>
<td>2.34</td>
<td>1.45</td>
</tr>
<tr>
<td>Trendwood</td>
<td>2.44</td>
<td>3.54</td>
<td>1.45</td>
</tr>
<tr>
<td>College View</td>
<td>1.40</td>
<td>2.19</td>
<td>1.56</td>
</tr>
<tr>
<td>The Knolls</td>
<td>2.69</td>
<td>3.04</td>
<td>1.13</td>
</tr>
<tr>
<td>*Overall Mean</td>
<td>2.14</td>
<td>3.36</td>
<td>1.57</td>
</tr>
</tbody>
</table>

*All cases considered

Chain Sinuosity

"Migration Sinuosity," a measure of the path wandering of a
vacancy chain, simply relates the actual path of the links in a chain
to the length of the expected path (see Chapter 2). A low index means
that there is little difference between actual and expected and a high
index implies that a greater difference exists.

The distribution of the Sinuosity Indices for the mapped chains
is shown as Table 3-7. Four of the initiator cells—Bethany, Meadowlane,
College View, and The Knolls—have approximately 40% of their total
chains in the lowest category—1.00 to 1.25. Only Wedgewood and Trend-
wood do not fit this apparent "norm," with the former initiator cell
having 24% of its chains in the 2.01-2.50 range. Referring to the
"Total" column, it can be seen that 37.4% of the 246 chains have
### TABLE 3-7

**SUMMARY OF ALL SINUOSITY INDICES**

<table>
<thead>
<tr>
<th>Si</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>#</td>
</tr>
<tr>
<td>1.00 - 1.25</td>
<td>18</td>
<td>40.9</td>
<td>26</td>
<td>41.3</td>
<td>13</td>
<td>26.0</td>
<td>92</td>
</tr>
<tr>
<td>1.26 - 1.50</td>
<td>8</td>
<td>18.2</td>
<td>9</td>
<td>14.3</td>
<td>7</td>
<td>14.0</td>
<td>41</td>
</tr>
<tr>
<td>1.51 - 2.00</td>
<td>8</td>
<td>18.2</td>
<td>12</td>
<td>19.0</td>
<td>9</td>
<td>18.0</td>
<td>46</td>
</tr>
<tr>
<td>2.01 - 2.50</td>
<td>2</td>
<td>4.5</td>
<td>5</td>
<td>7.9</td>
<td>12</td>
<td>24.0</td>
<td>23</td>
</tr>
<tr>
<td>2.51 - 3.00</td>
<td>2</td>
<td>4.5</td>
<td>2</td>
<td>3.2</td>
<td>3</td>
<td>6.0</td>
<td>11</td>
</tr>
<tr>
<td>3.01 - 3.50</td>
<td>3</td>
<td>6.8</td>
<td>4</td>
<td>6.3</td>
<td>3</td>
<td>6.0</td>
<td>5</td>
</tr>
<tr>
<td>3.51 - 4.00</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1.6</td>
<td>1</td>
<td>2.0</td>
<td>3</td>
</tr>
<tr>
<td>4.01 - 4.50</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1.6</td>
<td>2</td>
<td>4.0</td>
<td>3</td>
</tr>
<tr>
<td>4.51 - 5.00</td>
<td>1</td>
<td>2.3</td>
<td>2</td>
<td>3.2</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>5.01 - 5.50</td>
<td>1</td>
<td>2.3</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>5.51 - 6.00</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;6.01</td>
<td>1</td>
<td>2.3</td>
<td>1</td>
<td>1.6</td>
<td>0</td>
<td>0.0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>100.0</td>
<td>63</td>
<td>100.0</td>
<td>50</td>
<td>100.0</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>%</th>
<th></th>
<th>%</th>
<th></th>
<th>%</th>
<th></th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>99.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sinuosity Indices less than 1.25 and 54.1% are below 1.50.

Table 3-8 is the list of the mean Sinuosity Indices for all chains associated with each of the initiator cells. The mean values range from a high of 2.67 for College View to a low of 1.41 for "Knolls chains." The standard deviations range from 3.97 for College View down to .41 for The Knolls and the coefficients of variation also show great fluctuation.

<table>
<thead>
<tr>
<th>Initiator Cell</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bethany</td>
<td>1.86</td>
<td>1.44</td>
<td>.77</td>
</tr>
<tr>
<td>Meadowlane</td>
<td>2.12</td>
<td>3.10</td>
<td>1.46</td>
</tr>
<tr>
<td>Wedgewood</td>
<td>1.92</td>
<td>.85</td>
<td>.44</td>
</tr>
<tr>
<td>Trendwood</td>
<td>1.65</td>
<td>.72</td>
<td>.44</td>
</tr>
<tr>
<td>College View</td>
<td>2.67</td>
<td>3.97</td>
<td>1.49</td>
</tr>
<tr>
<td>The Knolls</td>
<td>1.41</td>
<td>.41</td>
<td>.29</td>
</tr>
<tr>
<td>Overall Mean</td>
<td>2.10</td>
<td>2.64</td>
<td>1.26</td>
</tr>
</tbody>
</table>

Azimuth Differential

As was discussed in Chapter 2, the "Azimuth-Differential" statistic describes the position of the first link in a vacancy chain with reference to the Central Business District in general and the Peak Land Value Intersection in particular. A low "differential" implies that the foundation move closely approximates a line from the PLVI to the Link-1 destination, while a high value means that the move-vector
does not "follow" the line.

Azimuth Differentials were computed for each of the vacancy chains tied to the six initiator cells (Table 3-9). As was the case for the Sinuosity Indices, the greatest proportion of the observations are in the lowest category—in this instance, 15 degrees or less difference between a chain's Link-1 origin-to-destination azimuth and an azimuth from the Peak Land Value Intersection to a chain's Link-1 destination. The highest percentages for Bethany, Meadowlane, Wedgewood, and The Knolls—34.1, 33.3, 30.0, and 41.7 respectively—are in the lowest category, while the highest percentages for Trendwood and College View—38.9 and 32.2—are in the 16-30 degree category. The "Total" column shows the distribution of percentages with 56.5% of all the first links having Azimuth Differentials of 30 degrees or less. On the other hand, 33% of the differentials were between 31 and 60 degrees. This latter figure is rather high and does show that a sizable number of the foundation moves are "not CBD-oriented." \(^{39}\)

The mean Azimuth Differentials according to the initiator cells that the chains are linked to can be seen in Table 3-10. The average angular differences range from a low of 24.67 degrees for The Knolls to a high of 41.22 for Meadowlane. The range in the standard deviations is sizable and the reader can note that the high mean for Meadowlane is also accompanied by a significant variation as measured by the standard deviation. The deviations for the other initiator cells all hover near 20, indicating relatively little variation.

\(^{39}\) Differentials of 15 degrees or less were termed "CBD-oriented." Those between 16 and 30 degrees were called "somewhat CBD-oriented," and others were said to be "not CBD-oriented" (see Chapter 2).
## TABLE 3-9

**SUMMARY OF ALL AZIMUTH DIFFERENTIALS**

<table>
<thead>
<tr>
<th>Ad</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>#</td>
</tr>
<tr>
<td>15° or less</td>
<td>15</td>
<td>34.1</td>
<td>21</td>
<td>33.3</td>
<td>15</td>
<td>30.0</td>
<td>2</td>
</tr>
<tr>
<td>16 - 30°</td>
<td>10</td>
<td>22.7</td>
<td>16</td>
<td>25.4</td>
<td>13</td>
<td>26.0</td>
<td>7</td>
</tr>
<tr>
<td>31 - 45°</td>
<td>10</td>
<td>22.7</td>
<td>5</td>
<td>7.9</td>
<td>10</td>
<td>20.0</td>
<td>1</td>
</tr>
<tr>
<td>46 - 60°</td>
<td>7</td>
<td>15.9</td>
<td>12</td>
<td>19.0</td>
<td>9</td>
<td>18.0</td>
<td>3</td>
</tr>
<tr>
<td>61 - 75°</td>
<td>1</td>
<td>2.3</td>
<td>4</td>
<td>6.3</td>
<td>2</td>
<td>4.0</td>
<td>5</td>
</tr>
<tr>
<td>76 - 90°</td>
<td>1</td>
<td>2.3</td>
<td>1</td>
<td>1.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>91 or more</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>6.3</td>
<td>1</td>
<td>2.0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>100.0</td>
<td>63</td>
<td>99.8</td>
<td>50</td>
<td>100.0</td>
<td>18</td>
</tr>
</tbody>
</table>
TABLE 3-10
MEANS, STANDARD DEVIATIONS, AND COEFFICIENTS OF VARIATION OF AZIMUTH DIFFERENTIALS

<table>
<thead>
<tr>
<th>Initiator</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bethany</td>
<td>28.02</td>
<td>20.01</td>
<td>.71</td>
</tr>
<tr>
<td>Meadowlane</td>
<td>41.22</td>
<td>53.33</td>
<td>1.29</td>
</tr>
<tr>
<td>Wedgewood</td>
<td>29.70</td>
<td>19.22</td>
<td>.65</td>
</tr>
<tr>
<td>Trendwood</td>
<td>38.33</td>
<td>21.46</td>
<td>.56</td>
</tr>
<tr>
<td>College View</td>
<td>31.24</td>
<td>18.36</td>
<td>.59</td>
</tr>
<tr>
<td>The Knolls</td>
<td>24.67</td>
<td>22.05</td>
<td>.89</td>
</tr>
<tr>
<td>Overall Mean</td>
<td>33.11</td>
<td>32.30</td>
<td>.98</td>
</tr>
</tbody>
</table>

Direction of Gain

The "Direction-of-Gain" Index was utilized to assess a vacancy chain's contribution to peripheral growth (see Chapter 2). A positive value indicates that the chain, as a whole, contributed to peripheral growth while a negative value represents a total central-city gain.

Direction-of-Gain indices were calculated for all 246 vacancy chains that contained at least two intra-urban links (Table 3-11). Bethany had the lowest percentage (6.8) of negative gains and The Knolls had the highest (16.7). In all, only 8.9% of all the chains scored negative gains, but the figures tend to substantiate certain qualitative inferences drawn from the maps of the vacancy chains—namely that Trendwood (11.1%), College View (11.9%), and The Knolls (16.7%) tend

The small number of cases for The Knolls, however, must be kept in mind.
### TABLE 3-11
SUMMARY OF ALL DIRECTION-OF-GAIN INDICES

<table>
<thead>
<tr>
<th>Dg (Miles)</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>#</td>
</tr>
<tr>
<td>Negative Gains</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 0.5</td>
<td>3</td>
<td>6.8</td>
<td>5</td>
<td>7.9</td>
<td>3</td>
<td>6.0</td>
<td>2</td>
</tr>
<tr>
<td>0.5 - 1.0</td>
<td>7</td>
<td>15.9</td>
<td>8</td>
<td>12.7</td>
<td>3</td>
<td>6.0</td>
<td>1</td>
</tr>
<tr>
<td>1.1 - 1.5</td>
<td>6</td>
<td>13.6</td>
<td>3</td>
<td>4.8</td>
<td>6</td>
<td>12.0</td>
<td>2</td>
</tr>
<tr>
<td>1.6 - 2.0</td>
<td>5</td>
<td>11.4</td>
<td>4</td>
<td>6.3</td>
<td>2</td>
<td>4.0</td>
<td>1</td>
</tr>
<tr>
<td>2.1 - 2.5</td>
<td>5</td>
<td>11.4</td>
<td>5</td>
<td>7.9</td>
<td>6</td>
<td>12.0</td>
<td>1</td>
</tr>
<tr>
<td>2.6 - 3.0</td>
<td>4</td>
<td>9.1</td>
<td>7</td>
<td>11.1</td>
<td>10</td>
<td>20.0</td>
<td>4</td>
</tr>
<tr>
<td>3.1 - 3.5</td>
<td>5</td>
<td>11.4</td>
<td>14</td>
<td>22.2</td>
<td>7</td>
<td>14.0</td>
<td>3</td>
</tr>
<tr>
<td>3.6 - 4.0</td>
<td>7</td>
<td>15.9</td>
<td>9</td>
<td>14.3</td>
<td>8</td>
<td>16.0</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 4.0</td>
<td>1</td>
<td>2.3</td>
<td>5</td>
<td>7.9</td>
<td>4</td>
<td>8.0</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>100.1</td>
<td>63</td>
<td>99.9</td>
<td>50</td>
<td>100.0</td>
<td>18</td>
</tr>
</tbody>
</table>

*Note: Gains are calculated as % of the total number in each category.*
to attract migrants from the less-central locations in the city whereas Bethany (6.8%), Meadowlane (7.9%), and Wedgewood (6.0%) are more closely tied to the more-central parts of Lincoln. This idea surfaces since movement to The Knolls, for example, from other peripheral areas is likely to result in a negative gain--because the destinations in the links of the various chains are generally closer to the PLVI than are the origins (which would indeed be the case with movement from more peripheral areas). It can also be seen from Table 3-11 that the highest number of occurrences for each of the initiator cells tends to be in the upper categories of gain--above 2.6 miles (see Chapter 2 for description of "gain categories"). In fact, 50.4% of all the chains contributed at least 2.6 miles to peripheral gain.

If one considers the "gains" for each of the links in the vacancy chains, some differences can be seen. Part A of Table 3-12 contains the absolute numbers of individual moves that scored positive gains, negative gains, or no gain at all according to the calculated Direction-of-Gain Index. Part B of the table simply depicts the overall percentage of moves that were positive gains for each link-group and initiator cell. The statistical superiority of the positive gains for Link 1 is seen clearly as four of the six initiator cells were above 90% (Part B of table). The percentages decline markedly, however, for the second links and even more for the third links. The higher fourth-link percentage may be a random occurrence caused by a smaller number of observations. Perhaps the most interesting aspect of the table, though, is the fact that second and third links are peripher-

---

41 The conclusion is, of course, almost automatic because of the peripheral location of the initiator cells.
TABLE 3-12
SUMMARY OF GAINS FOR INDIVIDUAL VECTORS

Part A: Absolute Number

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+ - 0</td>
<td>+ - 0</td>
<td>+ - 0</td>
<td>+ - 0</td>
<td>+ - 0</td>
<td>+ - 0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>42 2 0</td>
<td>53 10 0</td>
<td>48 2 0</td>
<td>18 0 0</td>
<td>55 4 0</td>
<td>8 3 1</td>
<td>224 21 1</td>
</tr>
<tr>
<td>2</td>
<td>27 16 1</td>
<td>41 20 2</td>
<td>26 23 1</td>
<td>9 6 3</td>
<td>36 20 3</td>
<td>7 3 2</td>
<td>146 88 12</td>
</tr>
<tr>
<td>3</td>
<td>10 5 2</td>
<td>10 9 4</td>
<td>14 8 0</td>
<td>5 2 1</td>
<td>11 13 2</td>
<td>1 1 0</td>
<td>51 38 9</td>
</tr>
<tr>
<td>4+</td>
<td>0 0 1</td>
<td>7 4 1</td>
<td>8 2 1</td>
<td>4 1 0</td>
<td>4 3 0</td>
<td>- - -</td>
<td>23 10 3</td>
</tr>
</tbody>
</table>

Part B: Percentage with Positive Gains

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>95.5</td>
<td>84.1</td>
<td>96.0</td>
<td>100.0</td>
<td>93.2</td>
<td>66.7</td>
<td>91.1</td>
</tr>
<tr>
<td>2</td>
<td>61.4</td>
<td>65.1</td>
<td>52.0</td>
<td>50.0</td>
<td>61.0</td>
<td>58.3</td>
<td>59.4</td>
</tr>
<tr>
<td>3</td>
<td>58.8</td>
<td>43.5</td>
<td>63.6</td>
<td>62.5</td>
<td>42.3</td>
<td>50.0</td>
<td>52.0</td>
</tr>
<tr>
<td>4+</td>
<td>0.0</td>
<td>58.3</td>
<td>72.7</td>
<td>80.0</td>
<td>57.1</td>
<td>-</td>
<td>63.9</td>
</tr>
</tbody>
</table>
eral moves only slightly more than half the time, i.e., it is approximately a 50-50 proposition. Of these two links, the percentages indicate that the second links are more likely to involve outward movement. These findings are in agreement with those related to Hypothesis 3, namely that the statistical relationship between "directional bias" and link number decreases as link number increases. Recall that the Chi-Square values for the direction-link number relationships were 130.17 for Link 1, 10.77 for Link 2, 8.30 for Link 3, and 8.68 for Link 4 (refer to page 104). Hence, the "gain indices" (Table 3-12 Part B) tend to substantiate the earlier findings related to directional bias.

Table 3-13 is a synopsis of the means, standard deviations, and coefficients of variation for the Direction-of-Gain Indices as grouped according to initiator cell. The average gain of chains ranges from 1.11 miles for The Knolls to 2.51 miles for Wedgewood. Standard deviations for the six initiator cells are comparable as are the coefficients of variation (with the exception of The Knolls which is somewhat higher).

Cross-Correlation of the Four Indices

The four vacancy-chain indices discussed up to this point--Spacing, Sinuosity, Azimuth Differential, and Direction-of-Gain--constitute what the author believes is a suitable means of describing and analyzing the spatial manifestations of intra-urban vacancy chains. The real intent of the thesis, however, is to utilize the four calculated

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The similarity among the Chi-Square values for Links 2, 3, and 4 is here pointed out. Though the relationship tended to be inverse (see previous discussion of Hypothesis #3), there was little actual difference in the values for the last three link-groups. This appears to be in line with the near "50-50 proposition" of peripheral movement.
<table>
<thead>
<tr>
<th>Initiator Cell</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bethany</td>
<td>2.07</td>
<td>1.32</td>
<td>.64</td>
</tr>
<tr>
<td>Meadowlane</td>
<td>2.34</td>
<td>1.50</td>
<td>.64</td>
</tr>
<tr>
<td>Wedgewood</td>
<td>2.51</td>
<td>1.27</td>
<td>.51</td>
</tr>
<tr>
<td>Trendwood</td>
<td>2.49</td>
<td>1.33</td>
<td>.53</td>
</tr>
<tr>
<td>College View</td>
<td>1.97</td>
<td>1.51</td>
<td>.77</td>
</tr>
<tr>
<td>The Knolls</td>
<td>1.11</td>
<td>1.35</td>
<td>1.21</td>
</tr>
<tr>
<td>Overall Mean</td>
<td>2.19</td>
<td>1.44</td>
<td>.66</td>
</tr>
</tbody>
</table>

measures as input to a multivariate analysis. In this way, it could be shown whether or not chains with similar scores on all four indices originate in the same initiator cells, i.e., whether or not there are identifiable "migratory streams." When conducting a multivariate classification, however, it is important to determine that the four developed indices truly are independent variables--in other words, the calculation of one index is not dependent upon another. This criterion has clearly been met in the case of the four vacancy-chain indices. As a simple means of judging the interrelationships of the four indices, they were cross-correlated in a matrix. The writer was also curious about the relation of all the indices to the number of links in a particular chain. Hence, the matrix was five-by-five in dimension. The results reveal very low correlations in all cases with the highest coefficient being only -.1904 between Sinuosity and Direction-of-Gain.
(Table 3-14). From this, the writer concludes that there is essentially no relationship between the four measures and that they are suitable for clustering in four-dimensional space.

**Discriminant Analysis**

The 246 vacancy chains with at least two intra-urban links were subjected to multivariate linear "Discriminant Analysis" for purposes of testing the hypothesis that "migratory streams" can be identified by "clustering" vacancy chains according to the scores on the four spatial indices (discussed in the previous paragraphs). "The objective of discriminant analysis is to classify objects [vacancy chains], by a

<table>
<thead>
<tr>
<th></th>
<th>Spacing</th>
<th>Sinuosity</th>
<th>Azimuth Differential</th>
<th>Direction of Gain</th>
<th>Number of Links</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spacing</td>
<td>-0.0268</td>
<td>-0.0524</td>
<td>-0.1655</td>
<td>0.1090</td>
<td></td>
</tr>
<tr>
<td>Sinuosity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azimuth</td>
<td>-0.0680</td>
<td>-0.1904</td>
<td>-0.1503</td>
<td>0.1033</td>
<td></td>
</tr>
<tr>
<td>Differential</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direction of Gain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Links</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Top figure is the Pearson Correlation (R) and the lower figure (in parentheses) is the statistical significance of the correlation.*
set of independent variables [the four spatial indices], into one of
two or more mutually exclusive and exhaustive categories [initiator
cells]."43 In other words, the question being asked in the current work
is, "can this multivariate statistical technique distinguish vacancy
chains associated with Bethany from those of Meadowlane, from those of
Wedgewood, etc.?'

All indices for the Spacing, Sinuosity, Azimuth-Differential,
and Direction-of-Gain variables were first standardized by conversion
to z-scores. These scores were then input to the discriminant algor-
ithm.44 Four discriminant functions were computed to maximize the
separation into groups. The eigenvalues and canonical correlations for
each of the four functions indicated that the functions were relatively
unimportant and that there was little total variance in the original
variables (see Table 3-15). The relative percentages for the eigen-
values (i.e., the importance of each of the functions) were 61.85,
25.57, 11.84, and 0.74 respectively. In addition, the Wilks'-Lambda
values were all relatively high (the larger the lambda, the less dis-
criminating power is present). Notice, too, that after the first
function was derived, the discriminatory power was no longer statis-
tically significant. The standardized discriminant function coeffic-
ients revealed that Direction-of-Gain made the greatest contribution to
the first function, Spacing was most important in the second function,
Sinuosity contributed the most to the third function, and Azimuth

43 Donald G. Morrison, "On the Interpretation of Discriminant
44 Norman H. Nie et al., Statistical Package for the Social
### TABLE 3-15
DISCRIMINANT STATISTICS FOR SPATIAL INDICES

<table>
<thead>
<tr>
<th>Discriminant Function</th>
<th>Eigenvalue</th>
<th>Relative Percentage</th>
<th>Canonical Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.09871</td>
<td>61.85</td>
<td>0.300</td>
</tr>
<tr>
<td>2</td>
<td>0.04081</td>
<td>25.57</td>
<td>0.198</td>
</tr>
<tr>
<td>3</td>
<td>0.01889</td>
<td>11.84</td>
<td>0.136</td>
</tr>
<tr>
<td>4</td>
<td>0.00117</td>
<td>0.74</td>
<td>0.034</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Functions Derived</th>
<th>Wilks' Lambda</th>
<th>Chi-Square</th>
<th>DF</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.8573</td>
<td>36.966</td>
<td>20</td>
<td>0.012</td>
</tr>
<tr>
<td>1</td>
<td>0.9419</td>
<td>14.373</td>
<td>12</td>
<td>0.278</td>
</tr>
<tr>
<td>2</td>
<td>0.9803</td>
<td>4.773</td>
<td>6</td>
<td>0.573</td>
</tr>
<tr>
<td>3</td>
<td>0.9988</td>
<td>0.281</td>
<td>2</td>
<td>0.869</td>
</tr>
</tbody>
</table>

Differential scored highest on the fourth function (Table 3-16). 45

The prediction results, however underscored the inability of vacancy chains to be classified properly according to the initiator cell of origin (Table 3-17). Notice, first of all, that the overall percentage of "grouped" vacancy chains correctly classified was only 20.3%. Considered on the basis of individual initiator cells, the table illustrates that The Knolls (50.0%) and Trendwood (38.9%) had 45 These were the highest values for each of the respective functions indicating which of the variables contributed the most to the particular function (the signs are ignored).
TABLE 3-16
STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS FOR SPATIAL INDICES

<table>
<thead>
<tr>
<th>Variable</th>
<th>Function 1</th>
<th>Function 2</th>
<th>Function 3</th>
<th>Function 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spacing</td>
<td>0.55552</td>
<td>-0.63116</td>
<td>0.06629</td>
<td>-0.57148</td>
</tr>
<tr>
<td>Sinuosity</td>
<td>0.05558</td>
<td>0.49574</td>
<td>0.72792</td>
<td>-0.51377</td>
</tr>
<tr>
<td>Azimuth</td>
<td>0.64767</td>
<td>-0.09886</td>
<td>0.42430</td>
<td>0.64924</td>
</tr>
<tr>
<td>Differential</td>
<td>0.78514</td>
<td>0.56068</td>
<td>-0.32965</td>
<td>-0.23512</td>
</tr>
</tbody>
</table>

the highest percentage correctly classified.46 Wedgewood, with 34% of its chains correctly classified, was third, followed by College View with 18.6%, Meadowlane with 11.1%, and Bethany with a very low 4.5%.

The plot of the groups and their centroids in reduced space further substantiated the poor discrimination of vacancy chains (Figure 3-12).47 The group centroids are located in close proximity with much overlap in the plotted chains.

In an effort to further study the classification, the vacancy chains were once again subjected to Discriminant Analysis, but this time, the variables were entered into the computations one at a time in stepwise fashion. The results of this procedure provide some additional insight into the vacancy-chain analysis.

46 The relatively low number of cases (12 and 18) for these neighborhoods should, however, be kept in mind when reviewing these results.

47 Notice that the greatest amount of clustering appears to be the Wedgewood chains (shown by "3's") around that group centroid ("W"). The Bethany chains are shown by "1's," while Meadowlane = "2," Trendwood = "4," College View = "5," and The Knolls = "6."
<table>
<thead>
<tr>
<th>Actual Group</th>
<th>No. of Cases</th>
<th>Predicted Group Membership</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
<th>Group 5</th>
<th>Group 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 (Bethany)</td>
<td>44.</td>
<td></td>
<td>2.</td>
<td>4.</td>
<td>8.</td>
<td>11.</td>
<td>6.</td>
<td>13.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.5%</td>
<td>9.1%</td>
<td>18.2%</td>
<td>25.0%</td>
<td>13.6%</td>
<td>29.5%</td>
</tr>
<tr>
<td>Group 2 (Meadowlane)</td>
<td>63.</td>
<td></td>
<td>2.</td>
<td>7.</td>
<td>17.</td>
<td>17.</td>
<td>8.</td>
<td>12.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.2%</td>
<td>11.1%</td>
<td>27.0%</td>
<td>27.0%</td>
<td>12.7%</td>
<td>19.0%</td>
</tr>
<tr>
<td>Group 3 (Wedgewood)</td>
<td>50.</td>
<td></td>
<td>2.</td>
<td>3.</td>
<td>17.</td>
<td>12.</td>
<td>7.</td>
<td>9.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.0%</td>
<td>6.0%</td>
<td>34.0%</td>
<td>24.0%</td>
<td>14.0%</td>
<td>18.0%</td>
</tr>
<tr>
<td>Group 4 (Trendwood)</td>
<td>18.</td>
<td></td>
<td>0.</td>
<td>2.</td>
<td>5.</td>
<td>7.</td>
<td>1.</td>
<td>3.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.0%</td>
<td>11.1%</td>
<td>27.8%</td>
<td>38.9%</td>
<td>5.6%</td>
<td>16.7%</td>
</tr>
<tr>
<td>Group 5 (College View)</td>
<td>59.</td>
<td></td>
<td>0.</td>
<td>6.</td>
<td>23.</td>
<td>4.</td>
<td>11.</td>
<td>15.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.0%</td>
<td>10.2%</td>
<td>39.0%</td>
<td>6.8%</td>
<td>18.6%</td>
<td>25.4%</td>
</tr>
<tr>
<td>Group 6 (The Knolls)</td>
<td>12.</td>
<td></td>
<td>2.</td>
<td>2.</td>
<td>1.</td>
<td>1.</td>
<td>0.</td>
<td>6.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16.7%</td>
<td>16.7%</td>
<td>8.3%</td>
<td>8.3%</td>
<td>0.0%</td>
<td>50.0%</td>
</tr>
</tbody>
</table>

Percent of "grouped" cases correctly classified: 20.33%
VACANCY CHAINS AND GROUP CENTROIDS

SPATIAL INDICES IN REDUCED SPACE

PLOT OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). * INDICATES A GROUP CENTROID.

Figure 3-12
The first variable to enter the algorithm was Direction-of-Gain.

After the calculations in the first step were completed, the overall percentage of vacancy chains that were correctly classified was only 17.9% (Table 3-18). At the second step in the computation, the Spacing Indices were input and the level of prediction rose only slightly (to 19.5%). After the third step when only three variables—Direction of Gain, Spacing, and Sinuosity—had been considered, the overall percentage correctly classified was 22.8, higher than when all four variables were entered. Azimuth Differential, then, contributed essentially nothing to the "separation" of vacancy chains.

TABLE 3-18
RESULTS OF STEPWISE DISCRIMINANT ANALYSIS
OF SPATIAL INDICES
(Percent Correctly Classified)

<table>
<thead>
<tr>
<th>Initiator Cell</th>
<th>Direction of Gain (Step #1)</th>
<th>Spacing (Step #2)</th>
<th>Sinuosity (Step #3)</th>
<th>Azimuth Differential (Step #4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bethany</td>
<td>4.5</td>
<td>2.3</td>
<td>11.4</td>
<td>4.5</td>
</tr>
<tr>
<td>Meadowlane</td>
<td>1.6</td>
<td>11.1</td>
<td>6.3</td>
<td>11.1</td>
</tr>
<tr>
<td>Wedgewood</td>
<td>60.0</td>
<td>46.0</td>
<td>48.0</td>
<td>34.0</td>
</tr>
<tr>
<td>Trendwood</td>
<td>0.0</td>
<td>27.8</td>
<td>22.2</td>
<td>38.9</td>
</tr>
<tr>
<td>College View</td>
<td>6.8</td>
<td>10.2</td>
<td>20.3</td>
<td>18.6</td>
</tr>
<tr>
<td>The Knolls</td>
<td>58.3</td>
<td>50.0</td>
<td>58.3</td>
<td>50.0</td>
</tr>
<tr>
<td>Total</td>
<td>17.9</td>
<td>19.5</td>
<td>22.8</td>
<td>20.3</td>
</tr>
</tbody>
</table>
The multivariate discriminant analysis failed to distinguish among vacancy chains according to the accumulated variations of the four spatial indices. Therefore, the original hypothesis, that regular "migratory streams" are associated with each of the initiator cells and can be identified by "clustering" certain spatial characteristics related to the vacancy chains, had to be rejected.

Summary and Conclusions

This chapter was intended as a spatial analysis of the mapped vacancy chains for Lincoln, Nebraska. While a portion of the investigation is rather "traditional" in nature—viz. the section addressing distance—much space is devoted to "newer" analyses which are perhaps best described as "exploratory." This adjective is applicable because of the total lack of prior precedent for such a methodology for a statistical examination of intra-urban vacancy chains. Despite the rejection of the principal hypothesis dealing with the statistical identification of intra-city "migratory streams," the author believes that the procedures utilized herein are capable of playing a formidable role in future studies of intra-urban residential mobility and are, therefore, important aspects of the chapter. While the procedures themselves are considered significant, certain generalizations from the analyses undertaken in Chapter 3 may be briefly highlighted.

Noteworthy findings regarding "distance" included the fact that 65.9% of the 688 intra-urban changes of residence examined in Lincoln were less than 2.99 miles in length. The importance of the geographical concept of "distance decay" was again shown. The foundation ingressions to the peripheral initiator cells were typically the longest of the
link-groups being about one mile longer than Links 2, 3, and 4. It was also demonstrated that the average distances for Links 2, 3, and 4 were similar. While the differences in the mean distances between Links 1 and 2 and between Links 1 and 2 and between Links 2 and 3 were statistically significant, such was not the case for the averages associated with Links 3 and 4.

As was stated in Chapter 1, much disagreement prevails regarding the spatial component called "directional bias," a contention most recently supported by W.A.V. Clark who noted that "... the empirical results of studies which have examined directional bias are at best inconclusive." The current work contributes some knowledge about movement directions as it was determined that the relationship between link number and direction tends to be inverse. In other words, the angles of moves in central areas are more "random" than those for outer areas.

The vacancies in the sequences of moves tied to each initiator cell generally "moved" closer to the CBD. Thus, vacancy chains beginning on the periphery of the city tend to end near the central city, so the outward movement of people was the dominant process.

The distribution of the move-origins for each link-group, however, was found to be random. In other words, the level of clustering of the move-origins does not become more clustered as link number increases. Rather, the deviations from clustered indicated that the reverse was true.

The principal aim of the chapter was to statistically distinguish vacancy chains associated with each of the initiator cells, thereby confirming the existence of separate "migratory streams." Four descriptive statistics, Spacing, Sinuosity, Azimuth Differential, and Direction-of-Gain, were utilized to quantify the spatial alignment of each chain. After confirmation of their independent nature through cross-correlation, the indices were input to multivariate linear Discriminant Analysis. The "direct" classification revealed that the Direction-of-Gain Index contributed the most to the separation of groups followed by Spacing, Sinuosity, and Azimuth Differential. It was also determined that the overall percentage of "grouped" vacancy chains correctly classified was only 20.3%. The stepwise Discriminant Analysis illustrated that the prediction of group membership could be slightly improved (to 22.8%) by using only the first three variables (excluding Azimuth Differential). Because the discriminant classification algorithm was capable of correctly grouping only about one chain in five, separate "streams" of migration within the city could not be identified.

The focus of this chapter has been on the use of only spatial variables in analyzing intra-urban residential mobility. Certainly some elements of the city's social-economic fabric must be incorporated when attempting an understanding of the processes related to the vacancy chain. These socio-economic variables form the crux of the research carried out in the succeeding chapter.
CHAPTER IV

A "HOUSING-ENVIRONMENT" ANALYSIS OF VACANCY CHAINS

Introduction

The purpose of Chapter 4 is to conduct a "housing-environment" analysis of the vacancy chains derived from the Lincoln mobility data. Whereas the preceding chapter was restricted solely to spatial variables, the current section includes certain socio-economic indicators as they relate to the previously discussed spatial configurations. In other words, the vacancy chains are again analyzed, but this time they are examined in terms of the "housing-environments" encountered in the sequences of moves. Because residential filtering is intrinsic to the whole idea of intra-city mobility, the filtering component of Lincoln's housing market is also assessed in Chapter 4. Several hypotheses are tested including one dealing with the multivariate classification of vacancy chains based on certain "housing indicators."

Analysis

Pertinent Hypotheses

Hypothesis 7: The majority of the Lincoln vacancy chains end in census tracts where the average dollar-value of the owner-occupied homes is below the mean for the city as a whole.

The stated hypothesis resulted principally from reasoning concerning general urban structure and the map of the areal means of suc-
cessive link origins (Figure 3-11). The illustration substantiated the hypothesis that vacancies tend to "move" toward the city center. A knowledge of urban structure would cause one to surmise that the more-central locations contain older dwellings that are relatively low in terms of dollar value. Since the general flow of migration in Lincoln is outward, and because many sequences of moves terminate near the CBD, the last move-origin should tend to be located within neighborhoods where the value of the owner-occupied homes is relatively low. Dzus found that "... successive housing units exhibited a gradual decline in mean rent/value down the chains of moves."¹ Romerill came to a similar conclusion adding that the socio-economic status of occupant households decreased as chain length increased.² If population groups of lesser economic means are to derive any benefit from moves into newer peripheral areas, the hypothesis should be substantiated.

Hypothesis 8: Prominent "beneficiary areas" within the city can be identified but the "poorest" neighborhoods (as judged on the basis of the average value of the owner-occupied homes) are not included in the three highest-ranking beneficiary areas.

The maps of the vacancy chains (Figures 3-1 through 3-6) led directly to the stated hypothesis since they revealed that although certain central-area neighborhoods were a part of the circulatory


systems of flows originating in the peripheral initiator cells, "Malone" and "Clinton," two depressed areas in Lincoln, were not well represented. Dzus provided further support for the hypothesis when he determined that "... lower income groups were not able to partake in the housing opportunities resulting from new construction." Dzus surmised that strategies other than new construction were required to meet the housing needs of the lower income groups in Windsor. Similarly, Lansing suggested that only about 333 (or 9.4%) of the movers will be poor out of the 3,545 people who move as a result of 1,000 new dwellings being constructed. If substantiated, a finding of this type would constitute a socio-economic discontinuity since the "worst" neighborhoods are not reached by the housing being opened in the sequences of vacancies.

Hypothesis 9: The filtering process is substantiated in at least 60% of the cases examined in Lincoln.

Lansing, Clifton, and Morgan, in a pioneering effort on vacancy chains, examined filtering through extensive interviews in many cities but found that the process was evident in only a slight majority of the moves. The hypothesis stated above, however, is derived directly from

3 Malone and Clinton had (in 1970) the lowest average values of owner-occupied homes in the city. The value for Malone was $8,600, while that for Clinton was an even-lower $8,300.

4 Dzus, 1975, op. cit., p. 150.

5 Ibid., p. 152.

6 J. B. Lansing, C. W. Clifton, and J. N. Morgan, New Homes and Poor People, Survey Research Center, University of Michigan, Ann Arbor, 1969, p. 66. Recall from Chapter 3 that the multiplier determined by Lansing and his colleagues was approximately 3.5.

7 Ibid., p. 45.
the work of Abu-Lughod and Foley who suggested that 60% of those who move within the same community are seeking to better their housing circumstances. The writer suspects that the results from Lincoln will approximate this 60% figure.

Hypothesis 10: **Residential filtering becomes less prevalent as link number increases. Therefore, "reverse-filtering" becomes more prevalent as link number increases.**

Grigsby showed that filtering was more pronounced in moves involving the suburbs than in the central city. Since it has already been shown that the vacancies tend to "move" closer to the CBD, it stands to reason that there should be an inverse relationship between link number and the extent of filtering. As a logical extension of that line of reasoning, if filtering is indeed most pronounced in Link 1 and it decreases in extent thereafter, the amount of "reverse-filtering" should increase. This latter process, whereby movers do not "improve" their housing situation, is one that has received only slight attention in the literature. The relative importance of the process is little known, although Maisel regarded it as extremely significant:

We know that some families move because they can no longer afford their houses. It would appear that in both percentage and absolute numbers those who move because of insufficient finances exceed those who move to upgrade their housing, although it is the

---


latter reason to which much of their mobility is attributed.  

R. J. Johnston underscored the importance of investigating this phenomenon by stating that "... a complementary spatial model of downward filtering is an important research need."  

Hypothesis 11: There is no significant difference in the average "dollar-value gain" (block of origin to block of destination) by "upward-filterers" and the average "dollar-value loss" by "downward-filterers."  

The hypothesis arose from reasoning concerning the preceding two hypotheses and from the intuitive feeling that little actual difference exists between the value of the owner-occupied homes in the blocks of origin and destination of "upward-" and "downward-filters." Thus, the author believes that the "filtering indicators" will reveal that the two processes are comparable in terms of the extent of "neighborhood change" that takes place.  

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10 S. J. Maisel, "Rates of Ownership, Mobility, and Purchase," Essays in Urban Land Economics, Berkeley: University of California Press, 1966, p. 107. Lansing et al., 1969, p. 45, also noted (with regard to filtering in their sample) that "the general tendency ... is in the expected direction, but there are substantial numbers of shifts in the opposite direction."  


12 The reader is reminded that the nature of the data precluded detailed analyses of "renters" versus "owner-occupiers." (see Chapter 2). Therefore, the examination related to Hypothesis #11 makes no distinction between the two groups of movers. Similarly, changes in tenure (e.g., renter to owner or vice-versa) were necessarily excluded from the investigations aimed at residential filtering.
Hypothesis 12: Vacancy chains can be "grouped" more accurately (according to the initiator cell of origin) by using selected "filtering indicators" than was done when only spatial variables were used.

The hypothesis was formulated in response to the failure of the four spatial indices to be clustered in four-dimensional space according to the initiator cells of origin of the respective vacancy chains. Since the "filtering indicators" used in the present chapter all deal with "housing-environments," and since existing models of urban growth and development assume some stratification of households/neighborhoods in the city, vacancy chains should be more readily "classified" with socio-economic data than spatial variables. The above statement, along with Hypothesis 6 (Chapter 3) is regarded by the author as one of the two most important in the thesis.

Chain Terminations

One of the most basic questions to be answered by a study of vacancy chains is the question of who finally benefits (in the sense of freed housing) from initial moves into the newer suburban housing. Because of the nature of the data used for this work, that question is best treated from the standpoint of the housing characteristics of the neighborhoods where vacancy chains tend to terminate.

Hypothesis 7: The majority of the Lincoln vacancy chains end in census tracts where the average dollar-value of the owner-occupied homes is below the mean for the city as a whole.

In testing the stated hypothesis, the mean of the average dollar-value of the owner-occupied homes for each census tract was calculated.

13 Throughout this work, the term "benefit" is used only in the sensing of housing being freed for occupancy.
This figure, derived from the 1970 census data, was $17,325.\textsuperscript{14} Placed within a geographical framework, the tracts with the lowest values tended to be around the CBD and the home-values generally increased with distance from the CBD, all of which agrees with "typical" urban structure (Figure 4-1).\textsuperscript{15}

In all, 175 of the 246 vacancy chains (71.1\%) with at least two intra-urban links ended in census tracts that were below the mean for the city as a whole. Of these, 144 (58.5\%) terminated in tracts that were one standard deviation below the mean and 31 (12.6\%) ended in tracts that were two standard deviations below the mean. Therefore, the hypothesis was accepted.

The statistics indicated that for every four initial moves into the suburban areas of Lincoln, almost three units eventually became vacant in areas of lower housing value, i.e., lower socio-economic status. But which of these neighborhoods saw the greatest amount of opened housing because of the foundation moves to the six initiator cells?

\textsuperscript{14}This represents the mean for 36 census tracts. Tract \#35 comprises the Lincoln Regional Center and was therefore excluded, as were Tracts \#6 (mostly the University of Nebraska-Lincoln), \#19 (largely CBD), \#32 and \#36.01 (the state penitentiary).

\textsuperscript{15}Note that only one tract \#38.01, (Trendwood), is as high as 4 standard deviations above the mean, although portions of 36.02 (The Knolls) are even more affluent.
AVERAGE VALUE OF OWNER-OCUPIED HOMES, 1970

(BY CENSUS TRACT)

Figure 4-1
Hypothesis 8: Prominent "beneficiary areas" within the city can be identified but the "poorest" neighborhoods (as judged on the basis of the average value of the owner-occupied homes) are not included in the three highest-ranking beneficiary areas.

When the 246 vacancy chains with at least two intra-urban links were considered in terms of their termination points, Tract #20 emerged as the most frequent "beneficiary area" (Figure 4-2). This tract, which was one standard deviation below the mean in terms of average home values (see Figure 4-1), encompasses much of the "Near-South" neighborhood, referred to so frequently in Chapter 3. A portion of the same neighborhood, much of which is zoned specifically for multiple-unit dwellings, extends into Tract #17. The latter census tract was three standard deviations above the mean as a beneficiary area. Tract #2.02, comprising part of University Place, was also three deviations above the mean for all tracts. These three census tracts saw the greatest number of chain terminations. Note that the Clinton area (Tract #4) was one standard deviation above the mean and thus was one of nine "lesser" beneficiary areas, but Malone (Tract #7) was actually below the mean of chain terminations by census tract. Therefore, the hypothesis was accepted.

When the prominent beneficiary areas are examined according to initiator cell, some intra-urban differences are apparent (Figure 4-3). The two initiator cells with the greatest number of vacancy


17 These census tract-initiator cell "affiliations" were determined simply by taking the mode of the chain terminations for each census tract and initiator cell.
STANDARD DEVIATIONS

NOTE: ONLY TRACTS ABOVE THE MEAN ARE SHOWN.

MEAN = 6.15
STANDARD DEVIATION = 6.04

Figure 4-2
Figure 4-3
chains, Meadowlane and College View, tended to have their linkages terminate in Census Tract #20.  
Tract #16 was the most prominent beneficiary area for chains originating in Wedgewood and Tract #2.02 benefited the most from initial moves to the Bethany initiator cell. The other two initiator cells, Trendwood and The Knolls, also had distinct areas of termination, but they were perhaps not as important because of the relatively low number of cases for each.

Residential Filtering

The extent of residential filtering within the housing market of Lincoln, Nebraska, during 1972 was assessed by investigating the "block-environmental filtering" that occurred between respective origins and destinations of the moves making up the vacancy chains. In other words, the "environments" at each point in a vacancy chain are compared by utilizing certain block-level data from the 1970 Census of Housing (see discussion of methodology, Chapter 2).

Hypothesis 9: The filtering process is substantiated in at least 60% of the cases examined in Lincoln.

Hypothesis 10: Residential filtering becomes less prevalent as link number increases. Therefore, "reverse-filtering" becomes more prevalent as link number increases.

The analysis of the filtering process vis-a-vis the testing of the hypotheses was carried out by analyzing the numerical changes in each of six selected "filtering indicators" in terms of the changing

---

18 The reader is reminded of the problems associated with the determination of the location where sequences actually end. Reference is made to the discussion of the philosophy of the vacancy chain (Chapter 1--especially footnote 24), the data source (Chapter 2), the explanation of the derivation and construction of chains (Chapter 2), and the "multiplier effect" (Chapter 3--especially footnote 11).
positions in the vacancy chains. The findings are summarized in six tables according to link-group and initiator cell. One table comprises the synopsis for each indicator, and each of those tables, in turn, contains three parts including: A) the mean values; B) the absolute number of cases with "positive" and "negative differences;" and C) the percentage of cases with positive differences. Part A of each table—the mean values—is a synopsis of the indicator-averages for each initiator cell and link-group, e.g., the mean value of owned homes for all Link-1 destinations tied to the Bethany initiator cell, the mean value of all owned homes for all Link-2 destinations associated with Bethany, and so on. The same is presented for the other five initiator cells.

Part B of each table simply illustrates the absolute number of movers in each link-group and initiator cell who "bettered" themselves according to a particular indicator, e.g., the number of "Link-1 Wedgewood movers" who migrated to a house where the block-level average value of homes is higher than that for the block just vacated. This is termed a "positive difference." A "negative difference" implies that "reverse filtering" has occurred, i.e., the move was to a block that is not "as good" as the one vacated—in terms of the indicator in question. Finally, Part C of each table simply lists the percentage of movers in each initiator cell and link-group that "bettered" themselves according to the indicator.

Owner Average Value

The first filtering indicator to be investigated was that of the "owner average value" of the homes in each of the blocks of destination and Table 4-1 is a digest of the statistics for that indicator. In
### TABLE 4-1

**OWNER AVERAGE VALUE**
(at successive destinations)

#### Part A: Mean Values (dollars)

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22,094</td>
<td>20,348</td>
<td>28,041</td>
<td>45,263</td>
<td>22,183</td>
<td>41,138</td>
<td>26,060</td>
</tr>
<tr>
<td>2</td>
<td>14,768</td>
<td>16,503</td>
<td>16,980</td>
<td>29,673</td>
<td>16,367</td>
<td>25,300</td>
<td>15,990</td>
</tr>
<tr>
<td>3</td>
<td>14,500</td>
<td>13,113</td>
<td>17,700</td>
<td>12,900</td>
<td>12,745</td>
<td>13,250</td>
<td>14,660</td>
</tr>
<tr>
<td>4+</td>
<td>*20,400</td>
<td>14,757</td>
<td>13,160</td>
<td>13,700</td>
<td>16,167</td>
<td>--</td>
<td>13,830</td>
</tr>
</tbody>
</table>

#### Part B: Absolute Number of Cases with Positive and Negative Differences

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>34</td>
<td>0</td>
<td>54</td>
<td>10</td>
<td>26</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
<td>13</td>
<td>23</td>
<td>11</td>
<td>7</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4+</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>15</td>
<td>84</td>
<td>28</td>
<td>36</td>
<td>7</td>
<td>61</td>
</tr>
</tbody>
</table>

*The number of cases in this and succeeding tables differs because of the variation in the completeness of the census data for some city blocks. Differences of zero were excluded from the results in all tables.

#### Part C: Percent of Cases with Positive Differences

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100.0</td>
<td>84.4</td>
<td>93.0</td>
<td>96.3</td>
<td>85.4</td>
<td>92.3</td>
<td>90.5</td>
</tr>
<tr>
<td>2</td>
<td>50.0</td>
<td>67.6</td>
<td>54.2</td>
<td>70.0</td>
<td>70.0</td>
<td>80.0</td>
<td>62.8</td>
</tr>
<tr>
<td>3</td>
<td>50.0</td>
<td>37.5</td>
<td>100.0</td>
<td>33.3</td>
<td>44.4</td>
<td>0.0</td>
<td>56.8</td>
</tr>
<tr>
<td>4+</td>
<td>*100.0</td>
<td>66.7</td>
<td>50.0</td>
<td>66.7</td>
<td>50.0</td>
<td>--</td>
<td>62.5</td>
</tr>
<tr>
<td>Total</td>
<td>76.9</td>
<td>75.0</td>
<td>80.5</td>
<td>83.7</td>
<td>74.4</td>
<td>80.0</td>
<td>77.5</td>
</tr>
</tbody>
</table>

*One observation only. This also applies to succeeding tables.
Part A of the table, the link-group averages for each of the initiator cells is shown. Note, first of all, that the averages for the Link-1 destinations for all six initiator cells are considerably higher than those for the other link-groups. The most significant column of Part A, though, is the link-group "Total" column where the figures clearly attest to the fact that the average owner values of homes decrease with position in the vacancy chains (see right-hand column). In other words, whereas the overall mean of the Link-1 averages is highest ($26,060), that for Link 2 is lower ($15,990), followed by Link 3 ($14,660), and finally Link 4 ($13,830).

While Part B of Table 4-1 denotes the absolute number of cases that "filtered up" versus those that "filtered down," Part C of the table is perhaps more concise. Noting the row totals for each link-group, first of all, it is seen that 90.5% of the Link-1 movers, 62.8% of the Link-2 movers, 56.8% of the Link-3 movers, and 62.5% of the Link-4 movers "improved" their residential environments. The column totals for each initiator cell reveal the fact that at least 74% of all the movers "attached to" each of the six initiator cells moved to blocks where the average owner values of homes were higher than those for the block just vacated. In sum, 77.5% of all the movers "bettered" themselves according to this particular filtering indicator.

Average Contract Rent

While the previous filtering indicator—owner average value—was aimed at assessing the monetary value of the owned homes in the blocks that were "contacted" by movers in the empirical vacancy chains, the indicator called "average contract rent" was intended to assess the
monetary value of the rental units. The results of the examination of filtering according to this "rental indicator" are presented as Table 4-2.

Part A of Table 4-2 is a summary of the average rent paid according to both the link-group of the chains and the initiator cell of origin. The only significant finding of this portion of the table appears to be listed in the "Total" column where it is seen that the average rent for all the Link-1 destinations in 1972 was $136 while rents for Links 2, 3, and 4 were $107, $102, and $97 respectively. These figures clearly demonstrate that, in general, average contract rent decreases with position in the vacancy chains.

In Part C of the table, the "Total" column records 86.1% of the Link-1 movers as migrating to blocks where the average rent was higher than that paid in their previous block of residence. The figures for Links 2, 3, and 4 are lower--62.1, 70.0, and 52.2% respectively. The column totals for each initiator cell indicate that when the link-groups are disregarded, the figures range from 62.3 to 72.6%. The investigation of this indicator concludes that 67% of all the movers "filtered upward."

**Owner Average Number of Rooms**

The third in the series of filtering indicators that were examined in this study reflects the average number of rooms in the owner-occupied housing. Again, the focus is on changes seen at successive positions in the vacancy chains.

The most significant finding in Part A of Table 4-3 is the difference between the overall Link-1 mean and those for Links 2, 3,
### TABLE 4-2

**AVERAGE CONTRACT RENT**
*(at successive destinations)*

#### Part A: Mean Values (dollars)

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>--</td>
<td>121</td>
<td>150</td>
<td>--</td>
<td>135</td>
<td>--</td>
<td>136</td>
</tr>
<tr>
<td>2</td>
<td>101</td>
<td>104</td>
<td>114</td>
<td>104</td>
<td>103</td>
<td>120</td>
<td>107</td>
</tr>
<tr>
<td>3</td>
<td>108</td>
<td>104</td>
<td>106</td>
<td>99</td>
<td>101</td>
<td>88</td>
<td>102</td>
</tr>
<tr>
<td>4+</td>
<td>88</td>
<td>91</td>
<td>94</td>
<td>83</td>
<td>109</td>
<td>--</td>
<td>97</td>
</tr>
</tbody>
</table>

#### Part B: Absolute Number of Cases with Positive and Negative Differences

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>1</td>
<td>13</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>6</td>
<td>25</td>
<td>13</td>
<td>9</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>0</td>
<td>7</td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>4+</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>7</td>
<td>45</td>
<td>17</td>
<td>40</td>
<td>3</td>
<td>38</td>
</tr>
</tbody>
</table>

#### Part C: Percent of Cases with Positive Differences

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>--</td>
<td>90.0</td>
<td>86.7</td>
<td>--</td>
<td>81.8</td>
<td>--</td>
<td>86.7</td>
</tr>
<tr>
<td>2</td>
<td>57.1</td>
<td>78.1</td>
<td>59.1</td>
<td>0.0</td>
<td>55.2</td>
<td>50.0</td>
<td>62.1</td>
</tr>
<tr>
<td>3</td>
<td>100.0</td>
<td>58.3</td>
<td>71.4</td>
<td>100.0</td>
<td>62.5</td>
<td>--</td>
<td>70.0</td>
</tr>
<tr>
<td>4+</td>
<td>0.0</td>
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<td>57.1</td>
<td>50.0</td>
<td>60.0</td>
<td>--</td>
<td>52.2</td>
</tr>
<tr>
<td>Total</td>
<td>66.7</td>
<td>72.6</td>
<td>69.0</td>
<td>50.0</td>
<td>62.3</td>
<td>50.0</td>
<td>67.0</td>
</tr>
</tbody>
</table>
### TABLE 4-3

OWNER AVERAGE NUMBER OF ROOMS
(at successive destinations)

#### Part A: Mean Values (rooms)

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.8</td>
<td>6.1</td>
<td>6.2</td>
<td>7.9</td>
<td>6.0</td>
<td>6.9</td>
<td>6.3</td>
</tr>
<tr>
<td>2</td>
<td>5.5</td>
<td>5.7</td>
<td>5.6</td>
<td>5.9</td>
<td>5.8</td>
<td>6.1</td>
<td>5.6</td>
</tr>
<tr>
<td>3</td>
<td>5.4</td>
<td>5.4</td>
<td>5.6</td>
<td>6.1</td>
<td>5.9</td>
<td>5.5</td>
<td>5.7</td>
</tr>
<tr>
<td>4+</td>
<td>5.4</td>
<td>5.6</td>
<td>5.9</td>
<td>6.5</td>
<td>5.6</td>
<td>--</td>
<td>5.7</td>
</tr>
</tbody>
</table>

#### Part B: Absolute Number of Cases with Positive and Negative Differences

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26</td>
<td>7</td>
<td>47</td>
<td>19</td>
<td>33</td>
<td>10</td>
<td>171</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>11</td>
<td>18</td>
<td>17</td>
<td>14</td>
<td>15</td>
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<td>8</td>
<td>26</td>
</tr>
<tr>
<td>4+</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>20</td>
<td>75</td>
<td>41</td>
<td>53</td>
<td>36</td>
<td>288</td>
</tr>
</tbody>
</table>

#### Part C: Percent of Cases with Positive Differences

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>78.8</td>
<td>71.2</td>
<td>76.7</td>
<td>92.6</td>
<td>77.5</td>
<td>81.8</td>
<td>77.7</td>
</tr>
<tr>
<td>2</td>
<td>60.7</td>
<td>51.4</td>
<td>48.3</td>
<td>54.5</td>
<td>62.2</td>
<td>40.0</td>
<td>55.2</td>
</tr>
<tr>
<td>3</td>
<td>66.7</td>
<td>77.8</td>
<td>27.3</td>
<td>66.7</td>
<td>66.7</td>
<td>0.0</td>
<td>56.5</td>
</tr>
<tr>
<td>4+</td>
<td>100.0</td>
<td>50.0</td>
<td>50.0</td>
<td>66.7</td>
<td>66.7</td>
<td>--</td>
<td>57.9</td>
</tr>
<tr>
<td>Total</td>
<td>70.6</td>
<td>64.7</td>
<td>59.6</td>
<td>79.5</td>
<td>69.5</td>
<td>61.1</td>
<td>67.0</td>
</tr>
</tbody>
</table>
and 4 (see right-hand column). While the mean for all the Link-1 destinations is 6.3 rooms per dwelling, those for the other links are all either 5.6 or 5.7—indicating no great differences at the other positions.

The absolute values of Part B of Table 4-3 were again utilized in compiling Part C, which reflects the same similarity among Links 2, 3, and 4. In this instance, though, the figures suggest that the movers in those latter link-groups migrated to blocks of larger owner-occupied homes approximately 56.5% of the time (average for Links 2, 3, and 4), while the figure for the Link-1 migrants is a significantly higher 77.7%. The column totals for each initiator cell range from 59.6% for Wedgewood to 79.5% for Trendwood. The grand-total percentage of movers who "bettered" their situation according to this indicator is 67%.

**Renter Average Number of Rooms**

Like the third filtering indicator, owner average number of rooms, this fourth measure is also aimed at assessing the extent to which movers are improving themselves in terms of living space. The statistics for the indicator called "renter average number of rooms" comprise Table 4-4.

In viewing the figures in Part A of Table 4-4, one is struck by the similarities between these statistics and those in Table 4-3. Note that the Link-1 mean is again the highest—this time 5.9 rooms—and the average values for the other three link-groups are essentially the same.

One difference between Table 4-4 and the table immediately
### TABLE 4-4

**RENTER AVERAGE NUMBER OF ROOMS**
(at successive destinations)

**Part A: Mean Values (rooms)**

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
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<td>6.0</td>
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</tr>
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<td>5.6</td>
<td>5.0</td>
<td>5.1</td>
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<td>5.4</td>
<td>4.2</td>
<td>5.8</td>
<td>4.1</td>
<td>5.7</td>
<td>3.4*</td>
<td>5.2</td>
</tr>
<tr>
<td>4+</td>
<td>5.4</td>
<td>3.9</td>
<td>5.9</td>
<td>4.3</td>
<td>5.5</td>
<td>--</td>
<td>5.0</td>
</tr>
</tbody>
</table>

**Part B: Absolute Number of Cases with Positive and Negative Differences**

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
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<td>24</td>
<td>0</td>
<td>9</td>
<td>2</td>
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<td>92</td>
</tr>
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<td>112</td>
</tr>
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<td>3</td>
<td>10</td>
<td>0</td>
<td>8</td>
<td>4</td>
<td>15</td>
<td>0</td>
<td>52</td>
</tr>
<tr>
<td>4+</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>58</td>
<td>0</td>
<td>43</td>
<td>18</td>
<td>80</td>
<td>4</td>
<td>272</td>
</tr>
</tbody>
</table>

**Part C: Percent of Cases with Positive Differences**

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>81.8</td>
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<td>--</td>
<td>96.2</td>
<td>--</td>
<td>94.8</td>
</tr>
<tr>
<td>2</td>
<td>100.0</td>
<td>74.2</td>
<td>92.0</td>
<td>66.7</td>
<td>92.5</td>
<td>100.0</td>
<td>88.9</td>
</tr>
<tr>
<td>3</td>
<td>100.0</td>
<td>66.7</td>
<td>100.0</td>
<td>66.7</td>
<td>100.0</td>
<td>0.0</td>
<td>89.7</td>
</tr>
<tr>
<td>4+</td>
<td>100.0</td>
<td>42.9</td>
<td>100.0</td>
<td>0.0</td>
<td>80.0</td>
<td>--</td>
<td>69.6</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>70.5</td>
<td>95.2</td>
<td>50.0</td>
<td>94.3</td>
<td>80.0</td>
<td>89.5</td>
</tr>
</tbody>
</table>

*One observation.*
preceding it is seen, though, in Parts B and C. The outstanding feature here is the very great number of cases that scored a positive difference on the indicator, i.e., "improved" as they moved to blocks where rental units were larger in terms of the number of rooms. The "Total" column of Part C of Table 4-4 indicates that all of the link-groups saw at least 69.6% or more of their movers "better" themselves, while the lowest value for the first three links is 88.9%. The column totals for the initiator cells are also extremely high with five of the six being above 70%. An overall total of 89.5% of all the movers scored a positive difference on this indicator. These very high totals are likely to be due to the fact that many families migrate within the city to increase their living space as they move through most stages of the life cycle. This would seem to be especially true in the case of renters.

Percent Owner-Occupied Units

The filtering indicator here called "percent owner-occupied units" refers to the percentage of all dwelling units in a city block that are owner-occupied. This figure was derived quite simply from the census information by dividing the number of "owner units" by the total number of dwelling units per block.

Table 4-5 illustrates the results of the analysis of this fifth filtering indicator. In Part A of the table, a general pattern of declining percentages with position in the vacancy chains is seen. The link-group or "row means" point out the fact that the Link-1 blocks of destination averaged 85.3% owner-occupied, 60.0% for Link 2, 50.6% for Link 3, and 45.4% for Link 4. Thus, the level of owner-occupied dwellings per block decreases with position in the vacancy chains and
### TABLE 4-5

PERCENT OWNER-OCUPIED UNITS
(at successive destinations)

#### Part A: Mean Values (%)

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80.1</td>
<td>87.9</td>
<td>58.2</td>
<td>84.5</td>
<td>60.7</td>
<td>87.6</td>
<td>85.3</td>
</tr>
<tr>
<td>2</td>
<td>51.0</td>
<td>52.5</td>
<td>51.0</td>
<td>73.7</td>
<td>51.5</td>
<td>73.3</td>
<td>60.0</td>
</tr>
<tr>
<td>3</td>
<td>36.9</td>
<td>45.8</td>
<td>46.2</td>
<td>54.0</td>
<td>46.8</td>
<td>36.8</td>
<td>50.6</td>
</tr>
<tr>
<td>4+</td>
<td>61.5</td>
<td>50.6</td>
<td>45.8</td>
<td>35.2</td>
<td>34.5</td>
<td>--</td>
<td>45.4</td>
</tr>
</tbody>
</table>

#### Part B: Absolute Number of Cases with Positive and Negative Differences

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>1</td>
<td>35</td>
<td>5</td>
<td>71</td>
<td>8</td>
<td>34</td>
<td>22</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>13</td>
<td>36</td>
<td>20</td>
<td>23</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
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<td>8</td>
<td>9</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>4+</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>25</td>
<td>124</td>
<td>39</td>
<td>72</td>
<td>52</td>
<td>31</td>
</tr>
</tbody>
</table>

#### Part C: Percent of Cases with Positive Differences

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>87.5</td>
<td>89.9</td>
<td>60.7</td>
<td>55.2</td>
<td>64.6</td>
<td>50.0</td>
<td>72.9</td>
</tr>
<tr>
<td>2</td>
<td>62.9</td>
<td>64.3</td>
<td>54.8</td>
<td>58.8</td>
<td>66.7</td>
<td>70.0</td>
<td>62.6</td>
</tr>
<tr>
<td>3</td>
<td>57.1</td>
<td>52.9</td>
<td>50.0</td>
<td>80.0</td>
<td>60.9</td>
<td>50.0</td>
<td>57.0</td>
</tr>
<tr>
<td>4+</td>
<td>0.0</td>
<td>72.7</td>
<td>75.0</td>
<td>25.0</td>
<td>66.7</td>
<td>--</td>
<td>63.3</td>
</tr>
<tr>
<td>Total</td>
<td>72.2</td>
<td>76.1</td>
<td>58.1</td>
<td>56.4</td>
<td>64.9</td>
<td>57.7</td>
<td>66.6</td>
</tr>
</tbody>
</table>
the figures indicate that more renters are encountered in the later positions in the chains.

In Part C of the table, the row totals for each link-group show similarities with previous tables as the Link-1 figure was highest (72.9%) and those for Links 2, 3, and 4 were more constant at a lower level (62.6, 57.0, and 63.3% respectively). The column totals for the initiator cells indicate that between 56.4% and 76.1% of the movers associated with each cell "filtered upward." The final statistic shows that 66.6% of all the movers judged on this indicator moved to blocks that had a greater percentage of owner-occupied units.

Percent One-Unit Structures

The feeling that "filtering upward" meant, in general, that movers would choose locations in blocks that had a greater amount of one-unit structures, led to the development of this indicator. The statistic is simply a ratio--the number of one-unit structures in a block to the total number of structures in that same block.

Table 4-6 is the synopsis of the indicator aimed at one-unit structures. The most interesting facet of Part A of the table is the link-group "Mean" column where a perfect decreasing progression of percentages is seen--from 94.9% for Link 1 all the way down to 52.5% for Link 4. This, again, is indicative of the preponderance of single-family units in the earlier links and rental units in the later links.

The row totals for each link-group in Part C of the table are again highest for Link 1 (in this case, 86.4%) with the figures for the other three link-groups lying at a fairly similar high level. The column percentage totals for the initiator cells range from 67.2% to
### TABLE 4-6

**PERCENT ONE-UNIT STRUCTURES**
(at successive destinations)

**Part A: Mean Values (%)**

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>99.6</td>
<td>99.8</td>
<td>92.6</td>
<td>100.0</td>
<td>82.3</td>
<td>99.4</td>
<td>94.9</td>
</tr>
<tr>
<td>2</td>
<td>74.2</td>
<td>62.8</td>
<td>65.4</td>
<td>79.9</td>
<td>72.7</td>
<td>80.9</td>
<td>69.8</td>
</tr>
<tr>
<td>3</td>
<td>69.2</td>
<td>67.9</td>
<td>59.0</td>
<td>62.3</td>
<td>60.3</td>
<td>45.9</td>
<td>64.0</td>
</tr>
<tr>
<td>4+</td>
<td>69.2</td>
<td>49.6</td>
<td>49.7</td>
<td>58.8</td>
<td>8.2</td>
<td>--</td>
<td>52.5</td>
</tr>
</tbody>
</table>

**Part B: Absolute Number of Cases with Positive and Negative Differences**

<table>
<thead>
<tr>
<th>Link</th>
<th>Bethany</th>
<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>1</td>
<td>37</td>
<td>11</td>
<td>25</td>
<td>7</td>
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<td>5</td>
<td>35</td>
</tr>
<tr>
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<td>10</td>
<td>3</td>
<td>12</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
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<td>8</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
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<td>17</td>
<td>109</td>
<td>34</td>
<td>27</td>
<td>10</td>
<td>80</td>
</tr>
</tbody>
</table>

**Part C: Percent of Cases with Positive Differences**

<table>
<thead>
<tr>
<th>Link</th>
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<th>Meadowlane</th>
<th>Wedgewood</th>
<th>Trendwood</th>
<th>College View</th>
<th>The Knolls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>100.0</td>
<td>77.1</td>
<td>100.0</td>
<td>65.8</td>
<td>87.5</td>
<td>86.4</td>
</tr>
<tr>
<td>2</td>
<td>62.5</td>
<td>58.0</td>
<td>62.2</td>
<td>66.7</td>
<td>67.3</td>
<td>81.8</td>
<td>64.0</td>
</tr>
<tr>
<td>3</td>
<td>76.9</td>
<td>75.0</td>
<td>68.4</td>
<td>66.7</td>
<td>69.6</td>
<td>0.0</td>
<td>69.6</td>
</tr>
<tr>
<td>4+</td>
<td>0.0</td>
<td>72.7</td>
<td>62.5</td>
<td>40.0</td>
<td>66.7</td>
<td>--</td>
<td>61.3</td>
</tr>
<tr>
<td>Total</td>
<td>76.4</td>
<td>79.6</td>
<td>69.6</td>
<td>73.0</td>
<td>67.2</td>
<td>76.2</td>
<td>73.3</td>
</tr>
</tbody>
</table>
79.6%. Overall, though, it is clear that 73.3% of all the movers migrated to blocks with a greater percentage of one-unit structures than the block they left. The analysis of the filtering indicators as applied to the mobility data utilized for this study has shown that "upward-filtering," whereby persons improve their residential situation, is the dominant process. Once again, consider the final percentages of movers filtering upward for each of the six indicators:

- Owner Average Value . . . . . . 77.5%
- Average Contract Rent . . . . . . 67.0%
- Owner Average Number of Rooms . . 67.0%
- Renter Average Number of Rooms . . 89.5%
- Percent Owner-Occupied Units . . 66.6%
- Percent One-Unit Structures . . 73.3%

The lowest percentage for any of the indicators, 66.6% for percent owner-occupied, leaves no doubt that the great majority of the movers are bettering their housing circumstances.

In sum, if the "performance" of the moves on the indicators is ranked, it can be said that over 73% of all the movers in the study moved to blocks where: 1) the average number of rooms in the rental units was greater; 2) the average value of the owned homes was higher; and 3) the percentage of one-unit structures was greater. It was also demonstrated that two-thirds or more of the moves were to blocks with: 4) a higher average number of rooms in the owner units; 5) higher rental costs; and 6) a higher percentage of owner-occupied units. When all of the positive gains were taken together, it was determined that 72.7% of the movers improved their housing situation (Table, 4-7, Part B). Therefore, Hypothesis #9, which stated that "the filtering process is substantiated in at least 60% of the cases examined in Lincoln,"
TABLE 4-7

SUMMARY OF FILTERING INDICATORS: ALL INITIATOR CELLS

Part A: Absolute Number of Cases with Positive and Negative Differences

<table>
<thead>
<tr>
<th>Link</th>
<th>Owner Average Value</th>
<th>Average Contract Rent</th>
<th>Owner Average Number Rooms</th>
<th>Renter Average Number Rooms</th>
<th>Percent Owner Occ.</th>
<th>Percent One Unit</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>201</td>
<td>21</td>
<td>31</td>
<td>5</td>
<td>171</td>
<td>49</td>
<td>92</td>
</tr>
<tr>
<td>2</td>
<td>81</td>
<td>48</td>
<td>64</td>
<td>39</td>
<td>80</td>
<td>65</td>
<td>112</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
<td>16</td>
<td>35</td>
<td>15</td>
<td>26</td>
<td>20</td>
<td>52</td>
</tr>
<tr>
<td>4+</td>
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<td>6</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>313</td>
<td>91</td>
<td>142</td>
<td>70</td>
<td>288</td>
<td>142</td>
<td>272</td>
</tr>
</tbody>
</table>

Part B: Percent of Cases with Positive Differences

<table>
<thead>
<tr>
<th>Link</th>
<th>Owner Average Value</th>
<th>Average Contract Rent</th>
<th>Owner Average Number Rooms</th>
<th>Renter Average Number Rooms</th>
<th>Percent Owner Occ.</th>
<th>Percent One Unit</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90.5</td>
<td>86.1</td>
<td>77.7</td>
<td>94.8</td>
<td>72.9</td>
<td>86.4</td>
<td>82.8</td>
</tr>
<tr>
<td>2</td>
<td>62.8</td>
<td>62.1</td>
<td>55.2</td>
<td>88.9</td>
<td>62.6</td>
<td>64.0</td>
<td>65.3</td>
</tr>
<tr>
<td>3</td>
<td>56.8</td>
<td>70.0</td>
<td>56.5</td>
<td>89.7</td>
<td>57.0</td>
<td>69.6</td>
<td>67.0</td>
</tr>
<tr>
<td>4+</td>
<td>62.5</td>
<td>52.2</td>
<td>57.9</td>
<td>69.6</td>
<td>63.3</td>
<td>61.3</td>
<td>61.3</td>
</tr>
<tr>
<td>Total</td>
<td>77.5</td>
<td>67.0</td>
<td>67.0</td>
<td>89.5</td>
<td>66.6</td>
<td>73.3</td>
<td>72.7</td>
</tr>
</tbody>
</table>

Part C: Percent of Cases with Negative Differences

<table>
<thead>
<tr>
<th>Link</th>
<th>Owner Average Value</th>
<th>Average Contract Rent</th>
<th>Owner Average Number Rooms</th>
<th>Renter Average Number Rooms</th>
<th>Percent Owner Occ.</th>
<th>Percent One Unit</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.5</td>
<td>13.9</td>
<td>22.3</td>
<td>5.2</td>
<td>27.1</td>
<td>13.6</td>
<td>17.2</td>
</tr>
<tr>
<td>2</td>
<td>37.2</td>
<td>37.9</td>
<td>44.8</td>
<td>11.1</td>
<td>37.4</td>
<td>36.0</td>
<td>34.7</td>
</tr>
<tr>
<td>3</td>
<td>43.2</td>
<td>30.0</td>
<td>43.5</td>
<td>10.3</td>
<td>43.0</td>
<td>30.4</td>
<td>33.0</td>
</tr>
<tr>
<td>4+</td>
<td>37.5</td>
<td>47.8</td>
<td>42.1</td>
<td>30.4</td>
<td>36.7</td>
<td>38.7</td>
<td>38.7</td>
</tr>
<tr>
<td>Total</td>
<td>22.5</td>
<td>33.0</td>
<td>33.0</td>
<td>10.5</td>
<td>33.4</td>
<td>26.7</td>
<td>27.3</td>
</tr>
</tbody>
</table>
was accepted. 19

Table 4-7, Part B, is also indicative of the fact that there was a general inverse relationship between link number and levels of filtering (i.e., the percent of cases with positive differences). If the percentage for Link 2 were slightly higher (or that for Link 3 lower), the relationship would be perfect inverse. At the same time, though, there was much similarity in the percentages for Links 2, 3, and 4. Nevertheless, because the overall proportion of the movers who "improved" their housing situation was highest in the first link, lower in the second, and lowest in the fourth, the hypothesis stating that "residential filtering becomes less prevalent as link number increases [and] 'reverse-filtering' becomes more prevalent as link number increases" was accepted.

Hypothesis 11: There is no significant difference in the average "dollar-value gain" (block of origin to block of destination) by "upward-filterers" and the average "dollar-value loss" by "downward-filterers."

The stated hypothesis was tested by means of the "T-Test for Independent Samples." 20 The mean and variance was calculated for all movers whose average value of the owner-occupied homes was given (in the census data) for both the block of move-origin and the block of move-destination. Those with "negative differences" comprised one sample and those with "positive differences" constituted a second.

19 A z-statistic of 12.80 as determined by the "Single-Sample Test for Individual Proportions" (see discussion of Hypothesis #1, Chapter 3) insured the statistical significance of this finding.

20 See discussion of Hypothesis #2, Chapter 3 for the formula.
The mean difference in dollar value between move origin and destination was $10,105 for "upward-filterers" but only $5,059 for "downward-filterers." These values, along with the variance and the number of cases, were input to the t-formulation to determine the significance of the difference between the two groups.21

A "t" of 4.96 with 401 degrees of freedom (significant beyond the .005 level) caused rejection of the hypothesis as stated. Worded differently, the finding was that there is indeed a statistically significant difference between the two groups in terms of the dollar-value differential at respective move-environments.

The implication of this finding which statistically distinguishes between "upward-" and "downward-filterers" seems to be that those who move up to better housing generally move to blocks where the average value of homes is significantly higher ($\bar{x} = $10,105). On the other hand, those who move down to neighborhoods with homes of lesser value do not move as far down the scale ($\bar{x} = $5,059) as the others who move upward. This finding may be at least partly explained by the fact that persons who filter up to better housing are more likely to be "owner-occupiers" while movers who filter down are more likely to be renters. The notion expressed here rests on two earlier findings: 1) the perfect inverse relationship between "percent owner-occupied" and link number (see Table 4-5), and 2) the general positive relationship between the level of "reverse-filtering" and link number. In other words, as link number increased, the level of owner-occupiers decreased and the amount of downward-filtering tended to increase.

21 The number of cases for individuals filtering upward was 311 while the number filtering downward was 92.
Thus, the distinction between "renter-moves" and "owner-moves" may be
the basis for explaining the situation. Though it is beyond the scope
of the current work, this rather unexpected finding certainly warrants
further investigation.

"Filtering Indicators" and Multivariate
Classification

Because of the failure of the Discriminate Analysis to correctly
group vacancy chains according to the initiator cell of origin on the
basis of the four geographic indices, Hypothesis #6, dealing with the
spatial identification of "migratory streams," was rejected. The
author, however believing that it should somehow be possible to make
initiator-cell distinctions among vacancy chains, decided to investi­
gate this line of reasoning in one other way.

Hypothesis 12: Vacancy chains can be "grouped" more accurately (accord­
ing to the initiator cell of origin) by using selected
"filtering indicators" than was done when only spatial
variables were used.

Initial Variable Selection

Since each intra-urban link of the 246 vacancy chains utilized
in the analysis carried out in Chapter 3 had certain "housing-environ­
ment information" attached to it--for the "tests" of filtering--it was
decided that this information could also be utilized in multivariate
classification. Therefore, useful and appropriate variables had to be
selected from among those available. The author decided, first of all,
that only information relating more directly to the "owner market"
would be utilized. In other words, two filtering indicators discussed in previous paragraphs, "renter average number of rooms" and "average contract rent," were excluded from consideration. This left four indicators, but each of these variables could be applied to each block of both move-origin and move-destination. Put another way, it was possible to apply the filtering indicator called "owner average value" to the Link-1 destinations, the Link-1 origins, the Link-2 origins, etc. Each could then serve as a separate variable. Because it was difficult to find complete "filtering-indicator information" for each block of origin and destination in a chain of more than two links, the author decided to use only chains with two links of complete information. Therefore, in an effort to maximize the number of chains which could be entered into the analysis, four filtering indicators for each Link-1 destination, Link-1 origin, and Link-2 origin were utilized. In all, 121 vacancy chains contained information for all twelve variables.

22 This decision was reached primarily because the probability of not having complete information (from the census data) was greater for the filtering indicators called "average contract rent" and "renter average number of rooms." Reference to the relative "n" sizes in Part B of Tables 4-1 through 4-6 substantiates this fact.

23 Because the Link-1 origin of a vacancy chain is the same as the Link-2 destination, the latter position in the chains was not used in this analysis.

24 Recall from the preceding section on residential filtering that the four variables referred to include: 1) owner average value; 2) owner average number of rooms; 3) percent owner-occupied units; and 4) percent one-unit structures. Each of these is applied to the Link-1 destination, Link-1 origin, and Link-2 origin for a total of twelve variables.
Cross Correlation: Final Variable Selection

Since a total of twelve variables were considered as having potential for classifying vacancy chains, it seemed possible that strong relationships might exist between certain pairs of the variables. To expose any significant collinearity, they were cross-correlated in a matrix, 12-by-12 in size. Because the total number of resultant correlations was too great for summarization in a tabular format, only the eight highest values are listed below:

**TABLE 4-8**

SELECTED "R-STATISTICS" FROM THE CORRELATION MATRIX FOR FILTERING INDICATORS

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.87</td>
<td>Owner Average Rooms L-1 Destination</td>
</tr>
<tr>
<td>(Sig. .001)</td>
<td>Owner Average Value L-1 Destination</td>
</tr>
<tr>
<td>0.82</td>
<td>% Owner Occupied L-2 Origin</td>
</tr>
<tr>
<td>(Sig. .001)</td>
<td>% One Unit L-2 Origin</td>
</tr>
<tr>
<td>0.77</td>
<td>% Owner Occupied L-1 Origin</td>
</tr>
<tr>
<td>(Sig. .001)</td>
<td>% One Unit L-1 Origin</td>
</tr>
<tr>
<td>0.55</td>
<td>Owner Average Rooms L-1 Origin</td>
</tr>
<tr>
<td>(Sig. .001)</td>
<td>Owner Average Value L-1 Origin</td>
</tr>
<tr>
<td>0.55</td>
<td>% Owner Occupied L-1 Destination</td>
</tr>
<tr>
<td>(Sig. .001)</td>
<td>% One Unit L-1 Destination</td>
</tr>
<tr>
<td>0.45</td>
<td>% Owner Occupied L-1 Destination</td>
</tr>
<tr>
<td>(Sig. .001)</td>
<td>Owner Average Value L-1 Origin</td>
</tr>
<tr>
<td>0.42</td>
<td>% One Unit L-1 Origin</td>
</tr>
<tr>
<td>(Sig. .001)</td>
<td>% One Unit L-2 Origin</td>
</tr>
<tr>
<td>0.39</td>
<td>Owner Average Rooms L-2 Origin</td>
</tr>
<tr>
<td>(Sig. .001)</td>
<td>Owner Average Value L-2 Origin</td>
</tr>
</tbody>
</table>
The eight correlations shown in Table 4-8 provide no startling revelations. The two variables for six of the eight correlations—

including the five highest—apply to the same "chain position." In other words, the 0.87 correlation between the owner average number of rooms and the owner average value is no surprise since both apply to the blocks at the Link-1 destination. Only the 0.45 and 0.42 correlations apply to filtering indicators at different chain positions. The former relationship (0.45) refers to the percent owner-occupied at the Link-1 destination and the owner average value at the Link-1 origin. The correlation of 0.42 relates the percent one-unit at the Link-1 origin to the percent one-unit at the Link-2 origin. Both cases can be explained, however, by the predominant upward filtering of movers and the associated "rate of improvement" in their housing conditions.

The intention in cross-correlating the variables, however, was to expose the strong bivariate relationships so that the number of variables could be reduced. This proved successful as the initial list of twelve variables was narrowed to six. As an illustration of the final variable-selection procedure, consider the 0.87 correlation between the two variables listed in Table 4-8. Obviously, both are not needed in distinguishing vacancy chains since they are so closely related. Therefore, one was eliminated from further consideration. The variable dropped, in this case the owner average number of rooms at the Link-1 destination, was the one with the lower coefficient of variation. 25

25 The reasoning here is that variables with higher coefficients of variation (when all 121 cases are considered together) are more likely to allow "chain separation." The coefficients of variation were used to determine which variable was eliminated except where a variable correlated above 0.39 with more than one other. In that case, the uncorrelated variable was used. The 0.39 level was determined by the author.
The eight highest correlations shown above were utilized in narrowing the list of variables to six: 1) percent one unit at the Link-1 origin; 2) owner average value at the Link-1 origin; 3) percent owner-occupied at the Link-1 destination; 4) owner average value at the Link-1 destination; 5) percent owner-occupied at the Link-2 origin; and owner average value at the Link-2 origin.

**Discriminant Analysis**

The 121 vacancy chains were subjected to multivariate classification for purposes of testing the hypothesis that the chains can be "grouped" according to the initiator cell of origin on the basis of the selected housing indicators. Linear Discriminate Analysis was employed once again in attempting to distinguish among the sequences of moves.

The six variables selected for inclusion in the clustering algorithm were first standardized by conversions to z-scores. When these values were input to the calculation, five discriminant functions were the result. In relation to those for the four spatial indices discussed previously (Chapter 3), the eigenvalues and canonical correlations for each of the five functions were higher, indicating that the functions based upon the housing variables were more important in separating vacancy chains (compare Table 4-9 with Table 3-15). The relative percentages for the eigenvalues, which are indicative of the importance of each of the functions, were much different than those for the spatial indices in that the first discriminant function alone
TABLE 4-9
DISCRIMINANT STATISTICS FOR FILTERING INDICATORS

<table>
<thead>
<tr>
<th>Discriminant Function</th>
<th>Eigenvalue</th>
<th>Relative Percentage</th>
<th>Canonical Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.76334</td>
<td>87.48</td>
<td>0.799</td>
</tr>
<tr>
<td>2</td>
<td>0.12860</td>
<td>6.38</td>
<td>0.338</td>
</tr>
<tr>
<td>3</td>
<td>0.09585</td>
<td>4.75</td>
<td>0.296</td>
</tr>
<tr>
<td>4</td>
<td>0.01881</td>
<td>0.93</td>
<td>0.136</td>
</tr>
<tr>
<td>5</td>
<td>0.00920</td>
<td>0.46</td>
<td>0.095</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Derived Functions</th>
<th>Wilks' Lambda</th>
<th>Chi-Square</th>
<th>DF</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.2846</td>
<td>143.268</td>
<td>30</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>0.7864</td>
<td>27.394</td>
<td>20</td>
<td>0.125</td>
</tr>
<tr>
<td>2</td>
<td>0.8875</td>
<td>13.603</td>
<td>12</td>
<td>0.327</td>
</tr>
<tr>
<td>3</td>
<td>0.9726</td>
<td>3.169</td>
<td>6</td>
<td>0.787</td>
</tr>
<tr>
<td>4</td>
<td>0.9909</td>
<td>1.045</td>
<td>2</td>
<td>0.593</td>
</tr>
</tbody>
</table>

"explained" 87.48% of the separation of groups.\(^{26}\) The Wilks' Lambda values were lower, indicating that more discriminating power was present than was the case with the spatial variables. While the discriminatory power was highly significant (0.0) before any functions were derived,\(^{26}\) by way of comparison, the relative percentages for the eigenvalues for the spatial indices were 61.85, 25.57, 11.84, and 0.74 respectively. As noted, the relative percentage for Function 1 for the housing indicators was 87.48, but the others were 6.38, 4.75, 0.93, and 0.46. Hence, three functions were at least somewhat important to the separation of groups based on the spatial indices, but only one was truly significant to the separation based on the housing indicators.
it was no longer significant after the calculation of the first function. In addition, the standardized discriminant function coefficients showed that the "owner average values for the Link-1 destinations" made the greatest contribution to the first function (see Table 4-10). The fact that the discriminant algorithm determined that the average home values of the initiator cells alone were (by far) the best "classifier" of vacancy chains was somewhat disappointing to the author. It had been hoped that variables at other chain positions would contribute significantly to produce a successful multivariate classification.

While the "percent owner-occupied at the Link-2 origins" was most important for the second function, the "owner average value at the Link-1 origin" contributed the most to the third function, the "owner average value at the Link-2 origin" scored highest on the fourth function, and the "percent one-unit structures at the Link-1 origins" was most significant to the fifth function (Table 4-10). The reader is again reminded, however, that the first discriminant function alone accounted for 87.48% of the separation of groups, while the other functions were much less important.

The prediction of the actual initiator cells based on these housing indicators was much more accurate than was the case for the spatial indices, though correct grouping still was not possible in the majority of cases (Table 4-11). Whereas the overall percentage of vacancy chains correctly classified was only 20.3% when strictly geographical variables were used, the "filtering indicators" allowed correct grouping of 42.2% of the chains. When individual initiator cells were considered, the analysis determined that Trendwood (63.6%) and Bethany (56.0%) had the majority of their chains correctly
classified. The Knolls (50.0%) was third in the rank-ordering, followed by College View (42.1%), Meadowlane (37.1%), and Wedgewood (24.0%).

The plot of the chains for each group around their respective centroids indicates some separation of groups, especially in the case of Trendwood (4's) and, to some extent, Bethany (1's) and The Knolls (6's) are distinctive (Figure 4-4).

In an effort to further examine the classification, the filtering indicators were subjected to stepwise Discriminant Analysis (as was 27 Again, the relatively low number of cases for Trendwood (11) and The Knolls (6) should be kept in mind when reviewing these results.

28 The group centroids themselves are labeled with the first letter of the name of the initiator cell. See Table 4-11 for the initiator-cell group numbers.
<table>
<thead>
<tr>
<th>Actual Group</th>
<th>No. of Cases</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
<th>Group 5</th>
<th>Group 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 (Bethany)</td>
<td>25</td>
<td>14.</td>
<td>7.</td>
<td>1.</td>
<td>0.</td>
<td>3.</td>
<td>0.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>56.0%</td>
<td>28.0%</td>
<td>4.0%</td>
<td>0.0%</td>
<td>12.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Group 2 (Meadowlane)</td>
<td>35</td>
<td>14.</td>
<td>13.</td>
<td>0.</td>
<td>0.</td>
<td>8.</td>
<td>0.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40.0%</td>
<td>37.1%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>22.9%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Group 3 (Wedgewood)</td>
<td>25</td>
<td>7.</td>
<td>4.</td>
<td>6.</td>
<td>1.</td>
<td>4.</td>
<td>3.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28.0%</td>
<td>16.0%</td>
<td>24.0%</td>
<td>4.0%</td>
<td>16.0%</td>
<td>12.0%</td>
</tr>
<tr>
<td>Group 4 (Trendwood)</td>
<td>11</td>
<td>0.</td>
<td>0.</td>
<td>1.</td>
<td>7.</td>
<td>0.</td>
<td>3.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0%</td>
<td>0.0%</td>
<td>9.1%</td>
<td>63.6%</td>
<td>0.0%</td>
<td>27.3%</td>
</tr>
<tr>
<td>Group 5 (College View)</td>
<td>19</td>
<td>3.</td>
<td>2.</td>
<td>6.</td>
<td>0.</td>
<td>8.</td>
<td>0.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.8%</td>
<td>10.5%</td>
<td>31.6%</td>
<td>0.0%</td>
<td>42.1%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Group 6 (The Knolls)</td>
<td>6</td>
<td>0.</td>
<td>0.</td>
<td>2.</td>
<td>1.</td>
<td>0.</td>
<td>3.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0%</td>
<td>0.0%</td>
<td>33.3%</td>
<td>16.7%</td>
<td>0.0%</td>
<td>50.0%</td>
</tr>
</tbody>
</table>

Percent of "grouped" cases correctly classified: 42.15%
VACANCY CHAINS AND GROUP CENTROIDS
FILTERING INDICATORS IN REDUCED SPACE

PLOT OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). * INDICATES A GROUP CENTROID.

Figure 4-4
done with the spatial variables). The first indicator considered was
the owner average value at the Link-1 destination (Table 4-12). At
this stage, the overall percentage of the vacancy chains that were cor-
correctly classified was 22.3%. The second variable to enter the calcula-
tion was the percent owner-occupied at the Link-2 origin, and the over-
all level of prediction rose to 35.5%. After the third step, when the
owner average values at the first-link origins were added, the percent
correctly classified stood at 40.5%. The level of prediction decreased
when the owner average values at the second-link origins were entered,
but it rose again to 43% when the percent owner-occupied at the first-
link destinations was added. The overall percent correctly classified
reached a high of 43% after the fifth step in the algorithm, and it
actually dropped slightly at the conclusion of the final step. Conse-
quently, the stepwise analysis illustrated that the 40% level of class-
ificaiton could be attained after only the first three variables were
entered. In addition, the indicators called "owner average value at
the Link-2 origins" and "percent one unit at the Link-1 origins" added
little to the vacancy-chain discrimination.

Although the initiator-cell associations could not be predicted
at as high a level as might be desired, it was determined that a Dis-
riminate Analysis of the housing-environment data was more fruitful
than that for the spatial indices. Therefore, Hypothesis #12 was
accepted.

Summary and Conclusions

The present chapter was intended as a "housing-environment
analysis" of the Lincoln vacancy chains. Three general topics were
### TABLE 4-12

RESULTS OF STEPWISE DISCRIMINANT ANALYSIS OF SELECTED FILTERING INDICATORS
(Percent Correctly Classified)

<table>
<thead>
<tr>
<th>Initiator Cell</th>
<th>OAVFLD* (Step #1)</th>
<th>POOSLO (Step #2)</th>
<th>OAVFLO (Step #3)</th>
<th>OAVSLO (Step #4)</th>
<th>POOFLD (Step #5)</th>
<th>POUFLO (Step #6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bethany</td>
<td>4.0</td>
<td>60.0</td>
<td>56.0</td>
<td>48.0</td>
<td>60.0</td>
<td>56.0</td>
</tr>
<tr>
<td>Meadowlane</td>
<td>40.0</td>
<td>22.9</td>
<td>42.9</td>
<td>42.9</td>
<td>42.9</td>
<td>37.1</td>
</tr>
<tr>
<td>Wedgewood</td>
<td>28.0</td>
<td>32.0</td>
<td>20.0</td>
<td>20.0</td>
<td>24.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Trendwood</td>
<td>36.4</td>
<td>54.5</td>
<td>72.7</td>
<td>72.7</td>
<td>63.6</td>
<td>63.6</td>
</tr>
<tr>
<td>College View</td>
<td>5.3</td>
<td>21.1</td>
<td>21.1</td>
<td>10.5</td>
<td>31.6</td>
<td>42.1</td>
</tr>
<tr>
<td>The Knolls</td>
<td>0.0</td>
<td>33.3</td>
<td>50.0</td>
<td>50.0</td>
<td>50.0</td>
<td>50.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>22.3</strong></td>
<td><strong>35.5</strong></td>
<td><strong>40.5</strong></td>
<td><strong>37.2</strong></td>
<td><strong>43.0</strong></td>
<td><strong>42.2</strong></td>
</tr>
</tbody>
</table>

*OAVFLD = Owner Average Value at the Link-1 Destination*

POOSLO = Percent Owner-Occupied at the Link-2 Origin

OAVFLO = Owner Average Value at the Link-1 Origin

OAVSLO = Owner Average Value at the Link-2 Origin

POOFLD = Percent Owner-Occupied at the Link-1 Destination

POUFLO = Percent One Unit at the Link-1 Origin

addressed in the chapter: 1) areas of vacancy-chain termination;
2) residential filtering; and 3) multivariate classification. Findings related to each of these topics can be briefly reiterated.

One very important aspect of an analysis of vacancy chains relates to the locations in the city where the sequences of moves tend to terminate. The present study determined that 71.1% of the chains ended in census tracts that were below the mean dollar-value of owner-occupied homes (in all census tracts). Of that total, only 12.6% terminated in tracts that were two standard deviations below the mean. These tracts (-2 s.d.) were the lowest in the city, but only a relatively small
percentage of the vacancy chains reached the poorest areas of the city. In fact, although prominent "beneficiary areas" within Lincoln were identified, two specific depressed areas, Clinton and Malone, did not "benefit" from intra-urban moves to the periphery of the city. Thus, although there were some difficulties in dealing with "chain terminations" (see footnote 18), the analyses in the current chapter seem to indicate that the poorest areas of the city do not always "benefit" from prior intra-urban moves to newer housing located on the edge of the city. This inference is in agreement with earlier findings as reported by Lansing, who suggested that only a small proportion of the movers in the sequences are "poor," and by Dzus, who determined that lower income groups in Windsor did not benefit by taking advantage of the housing opportunities resulting from new construction. 29

Chapter 4 included an examination of the filtering component of the housing market as it operates within Lincoln. The investigation was carried out by analyzing certain aspects of the blocks of origin and destination of the individual moves making up the vacancy chains. The analysis of these origins and destinations was based upon six "filtering indicators" derived from block-level census data. The author considers these indicators useful in assessing the changes in block-level environments that occur with intra-city movement. Thus, while the methodology alone has proven successful, several findings related to the filtering process itself can be reiterated.

The analysis of the filtering indicators as applied to the 1972 Lincoln mobility data has shown that "upward-filtering," whereby persons

29 Lansing, et. al., 1969, op. cit., p. 66; and Dzus, 1975, op. cit., p. 150.
improve their residential situation, is the dominant process. In all, 72.7% of the movers migrated to a "better housing environment." The extent of the upward-filtering tended, however, to decrease as link number increased. Consequently, persons in the second, third, and fourth positions in the sequences were increasingly less likely to improve their housing situation. In other words, "reverse-filtering" tended to become more prevalent as link number increased. When all links were considered together, 27.3% of all the moves were to "worse" housing environments. One very important finding with regard to the filtering process was the fact that there is a statistically significant difference between "upward-filterers" and "downward-filterers" in terms of the dollar-value differential at respective move-environments. The average level of increase in home value for the former group was $10,105 while the decrease for the latter group was only $5,059.

Although the concept of residential filtering is widely known, both suitable methodologies for analyses and empirical verifications themselves are generally lacking. While the current work has provided a useful methodology for investigating filtering, it has also determined that, in general, people do improve their housing situation after a move. At the same time, though, there is a considerable number of movers who do not improve their housing circumstances.

The Discriminant Analysis of the selected filtering indicators allowed 42.2% of the vacancy chains to be correctly classified as to the initiator cell of origin. By comparison, the overall percentage

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of vacancy chains that were correctly classified by the four spatial indices was only 20.3%. Hence, the socio-economic data is roughly twice as good as the spatial data in predicting the initiator cell to which a vacancy chain belongs. However, the most important variable in the first discriminant function, which accounted for 87.48% of the separation of groups, was the owner average values for the Link-1 destinations. This was evidenced by the fact that Trendwood (owner average value = $42,300) and Bethany (owner average value = $19,000), at opposite ends of the array of home values in the initiator cells (refer to Table 2-1), had the majority of their chains correctly classified. The stepwise Discriminant Analysis illustrated that the levels of prediction changed only slightly after the first three variables—"owner average value at the Link-1 destination," "percent owner-occupied at the Link-2 origin," and "owner average value at the Link-1 origin"—were added.

The main conclusion related to the Discriminant Analysis of the socio-economic data is that the technique can distinguish only about four vacancy chains in ten according to the initiator cell of origin (given the variables selected for use in the current work). Much of the discriminating power, though, rested merely upon the average values of homes in the initiator cells. The author believes that the approach has great potential, especially in larger cities where the range in home values, etc., is much greater and the individual mover has a wider selection of potential homesites. But additional work must be done before meaningful results can be obtained. Future investigators might even experiment with combinations of spatial and socio-economic variables.
CHAPTER V

RETROSPECT AND PROSPECT

- Intention and Nature of the Study

This thesis was intended to provide deeper insight into intra-urban migration through the use of the vacancy chain in a stricter geographical sense than had previously been done. The author believed at the outset that certain spatial patterns would surface in the course of surveying mapped intra-urban vacancy chains from both a cartographic and quantitative standpoint. In addition, it was felt that procedures for constructing, describing, and analyzing the linkages should be proposed and tested. The methodological evaluation, in effect, permeates much of the text and is doubtless a significant aspect of the research.

The present work has perhaps raised more questions than it has answered, which may be both appropriate and wholly desirable. The study, then, could probably best be termed as exploratory since it investigates one concept in a way not previously done. Though more closely attuned to the individual level, the work can, in a sense, also be considered remedial as it seeks to relate the traditional but often dissociated levels of mobility analysis—the individual and aggregate. Finally, although the approach is indeed new, it is focused upon residential change, a familiar yet powerful process that results in a continually changing urban mosaic.
Principal Findings

By way of summarizing the results of the research, the most expeditious method may be to list the findings as they relate to the hypotheses tested in Chapters 3 and 4.

Hypothesis 1: The majority of the moves comprising the vacancy chains will traverse little physical distance with at least 60% being less than three miles in length.

Hypothesis accepted - A total of 65.9% of all the intra-urban changes of residence were 2.99 miles or less in length.

Hypothesis 2: The length of a link is inversely related to its position in the chain (with the first links being the longest).

Hypothesis accepted - The first links in the vacancy chains were clearly the longest, averaging 3.0 miles, while other links were about one mile shorter. Although the average distances for Links 2, 3, and 4 were very similar (2.0, 2.1, and 1.8 miles respectively), there was a statistically significant difference between Links 2 and 3.\(^1\)

Overall, a general inverse relationship between link number and move distance prevailed.

Hypothesis 3: The statistical relationship between "directional bias" and link number decreases as link number increases.

Hypothesis accepted - Directional bias does generally decrease as link number increases. Moves involving central areas appear more

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\(^1\)Roman Dzus, "Residential Construction, Vacancy Chains, and Mobility Through Intra-Urban Space: A Case Study of the Windsor Metropolitan Area," Unpublished Master's Thesis, Department of Geography, University of Windsor, 1975, p. 155, found little difference in the mean lengths of "links" in Windsor, which is comparable to Lincoln in size.
random in direction than those involving outer areas.

Hypothesis 4: \textit{Vacancies in the sequences tend to "move" closer to the Central Business District.}

\textbf{Hypothesis accepted} - The overall outward movement of migrants is the dominant pattern.

Hypothesis 5: \textit{The degree of clustering of the link-origin varies with the position in the chain (with the Link-1 origins being the least clustered).}

\textbf{Hypothesis rejected} - The levels of clustering of the individual move origins do not increase as the link number increases. Rather, the reverse is true—the Link-1 distribution is closest to clustered and that for Link 4 is furthest from clustered.

Hypothesis 6: \textit{Regular "migratory streams" are associated with each of the initiator cells and can be identified by "clustering" certain spatial characteristics related to the vacancy chains.}

\textbf{Hypothesis rejected} - The multivariate linear Discriminant Analysis was incapable of "separating" vacancy chains according to the initiator cell of origin when the four spatial indices were used as input to the clustering algorithm. The classification showed that the Direction-of-Gain Index contributed the most to the separation of groups.

Hypothesis 7: \textit{The majority of the Lincoln vacancy chains end in census tracts where the average dollar-value of the owner-occupied homes is below the mean for the city as a whole.}

\textbf{Hypothesis accepted} - In all, 71.1% of the vacancy chains terminated in census tracts that were below the mean for the city. Of these, 58.5% ended in tracts that were one standard deviation below the mean and 12.6% terminated in tracts that were two standard deviations below the mean.
Hypothesis 8: Prominent "beneficiary areas" within the city can be identified but the "poorest" neighborhoods (as judged on the basis of the average value of the owner-occupied homes) are not included in the three highest-ranking beneficiary areas.

Hypothesis accepted - Two census tracts, 20 and 17, emerged as the most frequent beneficiary areas, and both comprise the "Near-South" neighborhood in Lincoln. Neither Clinton nor Malone, the two "poorest" neighborhoods in the city, was in the top-ranking group of beneficiary areas. Malone was actually below the mean of chain terminations by census tract, although Clinton was one standard deviation above the mean.

Hypothesis 9: The filtering process is substantiated in at least 60% of the cases examined in Lincoln.

Hypothesis accepted - A total of 72.7% of all the movers improved their housing situation according to the six "filtering indicators" used in this work. This "upward-filtering" was clearly the dominant process.

Hypothesis 10: Residential filtering becomes less prevalent as link number increases. Therefore, "reverse-filtering" becomes more prevalent as link number increases.

Hypothesis accepted - A general inverse relationship between link number and levels of upward-filtering was found. Reverse-filtering was most prevalent in the later links.

Hypothesis 11: There is no significant difference in the average "dollar-value gain" (block of origin to block of destination) by "upward-filterers" and the average "dollar-value loss" by "downward-filterers."

Hypothesis rejected - There is a statistically significant difference between the two groups in terms of the dollar-value differ-
ential at respective move-environments. The average level of increase in home value for the "upward-filterers" was $10,105 while the decrease for the "downward-filterers" was only $5,059.

Hypothesis 12: Vacancy chains can be "grouped" more accurately (according to the initiator cell of origin) by using selected "filtering indicators" than was done when only spatial variables were used.

Hypothesis accepted - While the percentage of vacancy chains correctly classified by the discriminant-analysis procedures was 20.3% when strictly geographical variables were used, the "filtering indicators" allowed correct grouping of 42.2% of the chains. The variable called "owner average values for the Link-1 destinations" contributed the most toward the separation of groups.

The hypotheses and results cited above are helpful in generalizing about sequences of moves in urban areas. By way of summarizing what might be expected in cities of comparable size, several characteristics of the movement process as it operated in Lincoln, Nebraska, can be briefly highlighted.

At the individual level, the typical change of residence traversed little physical distance, and, if it was a move directly to the urban periphery, the length was about 3 miles. The "foundation moves" tended to be directionally biased and the overall distribution of the move-origins was more clustered than was the case for the points of origin for the other link-groups. The initial moves to the edge of the city were likely to involve "upward-filtering" and the migrants themselves were probably owners rather than renters.

If an individual move constituted a second, third, or fourth link, however, it was much shorter, averaging about 2 miles in length.
The moves comprising these other link-groups were less biased directionally, with the Link-2 moves being more biased than the other two groups. The later links tended to be more "random" in direction, and their move-origins were not as clustered as the first-link origins. The percentages of "owner-occupiers" decreased with link number so the migrants in the later links were more likely to be renters. The occurrence of "downward-filtering" tended to increase with the link number.

On the whole, many changes of both a geographic and socioeconomic nature occur as the vacancies "move" through the sequences getting ever closer to the CBD. As already stated, the distance of the individual moves tends to become shorter, the moves become less biased directionally, and the move-origins are progressively less clustered. In addition, the average dollar-value of the blocks encountered in the chains decreases as does the average rent paid, the percentage of owner-occupied units, and the percentage of one-unit structures. The average number of rooms in the blocks contacted is fairly constant for both "owner-occupiers" and "renters" in Links 2, 3, and 4. A greater percentage of renters, however, move to blocks with larger dwelling units when they change residential locations than do owners. Thus, the former group seems more likely to increase their living space. The average level of increase in home value for "upward-filterers" is larger than the average decrease for the "downward-filterers." In general, though, the vast majority of the movers improve their "residential environments" with a change of address.

Considered at the "chain level," though the vacancies generally "moved" closer to the Central Business District where they terminated
in neighborhoods of less-than-average home value, the chains tended not to reach the "poorest" areas of the city. Thus, these neighborhoods did not "benefit" from the initial moves to the urban periphery.

One of the disappointing aspects of the study was the inability of the vacancy-chain approach to isolate distinct "channels of migration" within the city. It appears that the lack of a consistent geographic/geometric pattern in the second, third, and fourth links was the major confounding factor in the search for "migratory streams."

This similarity in the later links was one of the recurring elements of the work. Whatever spatial or housing characteristic was being considered, little in the way of actual differences among the second, third, and fourth links was found. Consider, for example, the following table (5-1) which is a synopsis of all the "indicators" by link-group, and compare the values for Links 2, 3, and 4.

### TABLE 5-1

**SUMMARY OF ALL SPATIAL AND FILTERING INDICATORS BY LINK-GROUP**

<table>
<thead>
<tr>
<th>Link</th>
<th>(A^*)</th>
<th>(B)</th>
<th>(C)</th>
<th>(D)</th>
<th>(E)</th>
<th>(F)</th>
<th>(G)</th>
<th>(H)</th>
<th>(I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.0</td>
<td>130.17</td>
<td>26,060</td>
<td>136</td>
<td>6.3</td>
<td>5.9</td>
<td>85.3</td>
<td>94.9</td>
<td>91.1</td>
</tr>
<tr>
<td>2</td>
<td>2.0</td>
<td>10.77</td>
<td>15,990</td>
<td>107</td>
<td>5.6</td>
<td>5.1</td>
<td>60.0</td>
<td>69.8</td>
<td>59.4</td>
</tr>
<tr>
<td>3</td>
<td>2.1</td>
<td>8.30</td>
<td>14,660</td>
<td>102</td>
<td>5.7</td>
<td>5.2</td>
<td>50.6</td>
<td>64.0</td>
<td>52.0</td>
</tr>
<tr>
<td>4+</td>
<td>1.8</td>
<td>8.68</td>
<td>13,830</td>
<td>97</td>
<td>5.7</td>
<td>5.0</td>
<td>45.4</td>
<td>52.5</td>
<td>63.9</td>
</tr>
</tbody>
</table>

*\(A^*\) = Mean Distances (miles)  
B = Direction (Chi Square)  
C = Owner Average Value (dollars)  
D = Average Contract Rent (dollars)  
E = Owner Average Rooms  
F = Renter Average Rooms  
G = Percent Owner Occupied  
H = Percent One Unit  
I = Links with Positive Gains (percent according to the Direction-of-Gain Index)*
If these same indicators are each ranked by link-group and an average rank is calculated, one concludes that there is much similarity in the characteristics of the later links (Table 5-2). As was suggested above, it was this lack of distinct differences among the second, third, and fourth links that caused the rejection of the hypothesis concerning the existence of "channels of migration" in the city.

TABLE 5-2
RANK-ORDERING OF ALL SPATIAL AND FILTERING INDICATORS BY LINK-GROUP

<table>
<thead>
<tr>
<th>Link</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2.6</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>2.9</td>
</tr>
<tr>
<td>4+</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>3.4</td>
</tr>
</tbody>
</table>

**Overall Contributions**

Though the current work is considered to be exploratory, the author nevertheless regards it as a contribution to the field of geography. From the thesis as a whole, specific aspects can be highlighted as adding to the body of knowledge of urban geography, and more specifically, intra-urban residential mobility.

In the opinion of the writer, a major contribution of the thesis lies in the fact that it represents the first systematic attempt at a statistical identification of intra-urban "migratory streams." The fact that the principal hypothesis of the thesis had to be rejected (because the four spatial indices did not allow consistent and accurate grouping of vacancy chains) may mean that the so-called "channels of migration"
do not exist in medium-sized American cities. After analyzing the data in the present work, the author suspects that this is indeed the case. On the other hand, though, perhaps the "streams" do exist but were not identified because the methodology that was developed was not "powerful" enough to do the job. If that is the case, the procedures utilized here-in, though exploratory in nature, should provide the basis for further development of a more formal means of vacancy-chain analysis.

Also related to the contribution associated with the procedures is the fact that all of the prior empirical studies focused upon vacancy chains begun strictly through new construction. This work introduced the concept of the "initiator cell," and chains were begun in ways other than solely through new construction. The initiator-cell idea also served as an organizing concept (e.g., "Wedgewood chains").

The writer believes that the dissertation contributes by elucidating an alternate method of constructing chains. Virtually all previous empirical studies of the vacancy chain were based upon personal interviews. Despite certain difficulties (discussed in Chapter 2), the procedures outlined in this thesis allow historical studies of vacancy chains. One could, for example, construct linkages for Lincoln using 1960 data if he so desired. Quite obviously, this cannot be done with interviewing techniques. The procedures developed also clear the way for computerized linkage construction and mapping. Careful screening of customer responses by the local utility companies—to insure complete addresses—would provide a "clean" data file from which linkages could be determined automatically.

The dissertation provides the first real look at the spatial
manifestations of intra-urban vacancy chains. Though derived through very simplistic means, the map of Mean Centers (Figure 3-11) is, to the knowledge of the writer, the only empirically derived spatial model of intra-city mobility in existence. The one way a model such as this can be derived is through vacancy-chain procedures simply because it is the only way to classify the individual move origins (e.g., Link-3 origins). This "centrographic model" for Lincoln proves that, on the whole, vacancies do "move" closer to the CBD and "classical" notions regarding urban spatial structure are supported.

Another contribution stems from the rather brief look at the filtering component of Lincoln's housing market. Unlike most studies of filtering, the present work concluded that "upward-filtering," whereby movers "better" themselves, is clearly the dominant process. The findings related to "reverse-filtering" could serve to initiate research in that important area. The methods used to examine the filtering process seem, to the writer, to be workable and logical. Once again, the freedom from interviewing should be noted.

The author believes that the work contributes, if in no other way, merely by the fact that it focuses on the concept of the vacancy chain, an idea that has received little treatment in the past. The advantages in using this approach to study residential movement in space include the fact that one can still maintain the specificity of the individual level on the one hand and can link related moves on the other. As has been stated several times in preceding chapters, each move is only one link in a much longer sequence of changes and it is only proper that these single moves should be treated within the framework of their real-world linkages. In addition, a certain amount of
organization is imparted to analyses based on the vacancy chain because links can be classified as to their position in the sequence (e.g., Link 2). Similarly, specific "mobility subsystems" can be studied simply by selecting certain "initiator neighborhoods" and mapping the chains tied to them (e.g., "Bethany chains"). Thus, the chains can be classified in this fashion. In short, the concept is a worthy one from a geographic standpoint because it allows us to relate the individual to the aggregate level with greater meaning and provides a better means of organizing residential movement into a suitable framework.

Evaluation of the Vacancy-Chain Approach

Problem of Linkage Construction

In retrospect, it seems that one of the most difficult aspects of this work was the actual construction of the intra-urban vacancy chains. The source of the problem was the lack of completeness of the addresses as recorded in the "Daily Moving Record"—though that source was undoubtedly the best to be found in the city. More specifically, the difficulty arose because of the tendency of the data source to omit the apartment number for moves from multiple-family dwellings (see discussion in Chapter 2). Consequently, when a particular vacancy chain reached the rental market, it was more likely to terminate. It is believed, however, that the rate of chain terminations as caused by this data inconsistency is no greater than the interview failures one would experience were that more expensive and time-consuming methodology used (see Chapter 3, Footnote 11).
Utility of the Approach for Description, Analysis, and Explanation

The purpose of this dissertation was to use the vacancy chain to describe, analyze, and explain patterns of intra-urban migration. It seems appropriate, then, by way of conclusion, to evaluate the vacancy chain as a means of accomplishing the stated purpose.

When the study was in the early stages of formulation, there were great expectations concerning the ability of mapped vacancy chains to describe intra-urban movement in Lincoln. It turns out that the expectations were warranted in some ways and were not in others. Looking first at the problems, one need only refer back to Figures 3-1 through 3-6 where it can be seen that the links of the vacancy chains are still single vectors which result in considerable confusion when portrayed graphically. The many varied orientations of the individual moves makes it difficult to perceive geographical patterns. The vacancy chain did not ease this problem of the single-vector approach (see discussion in Chapter 1).

At the same time, though, some positive statements can be made concerning the ability of the vacancy chain to enhance the description of intra-city residential mobility. First, only the chain allows one to identify neighborhoods well down the line of sequences that are parts of circulatory subsystems related to certain initiator cells. Recall from Chapter 3, for example, how Belmont was described as a part of the circulatory subsystem tied to Bethany. Secondly, the maps seem more systematic and logical when links are identified as to their position in the sequences. This allows one to search for "mini patterns" or subsystems within the larger circulatory systems while still viewing
the overall pattern of flows. This logic is well shown in the map of the chains associated with College View (Figure 3-5) where the long first links can be contrasted to the many shorter, randomly oriented moves near the CBD that make up the later links. The logic of the organization is also seen in the maps of the vector origins (Figures 3-7 through 3-10) where the pattern seems to "move" toward the CBD.

The organization associated with the concept of the vacancy chain, though, is seen most clearly in the map of the areal means (Figure 3-11). The latter illustration no doubt allows a good description of overall movement patterns. Consequently, it can be seen that while there are certain problems in using the vacancy chains—in a qualitative sense—to describe mobility patterns, they can be very effective when simple descriptive statistics are added to the methodology.

The strength of the vacancy chain appears to be best illustrated when included in an analytical framework such as that suggested in the thesis. While the procedures in some ways allow better description, they, more importantly, form the basis for more systematic and scientific analyses. Again, only the concept of the vacancy chain allows the vectors to be designated as to their place within the mobility system, which makes for a more meaningful analysis. Single vectors can be investigated in terms of their distance and/or directional bias, but the more significant measures—e.g., Spacing, Sinuosity, Azimuth Differential, and Direction-of-Gain Indices—are based upon sequences of moves. 2 These statistics can then serve as input to more powerful

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2 The Azimuth Differential is actually based on one link—the foundation move—but it has more meaning when considered in terms of the overall chain methodology (see discussion in Chapter 2).
algorithms such as Discriminant Analysis. The author suggests that the vacancy chain offers the organizing concept that has long been lacking in prior analyses of intra-city residential mobility.

As Amedeo and Golledge have noted, explanation in geography generally refers to accounting for spatial variation. The current study has also assessed the utility of the vacancy chain in accounting for, i.e., explaining, the spatial variation in the patterns of intra-urban residential mobility as manifested in the city of Lincoln, Nebraska. As suggested many times previously, one advantage of using the vacancy-chain approach is its "multi-level flexibility." In other words, single links in chains can be analyzed at the individual level, links can be combined to form chains and examined at that level, and the chains can be aggregated as was done with the aid of the basic centrographic technique, Mean Center. As the "link-level," the vacancy chains have the same individual-level explanatory power as single-vector approaches. When the links are combined to form the chains, however, a whole new level of analysis surfaces. As seen in Chapters 3 and 4, several techniques can be applied to these chains which can make the explanation of the processes causing the patterns more manageable.

Future Research

As noted at the outset of this chapter, the dissertation has raised more questions than it has answered. It would have been desirable to address some of those questions in the present work, but, because of certain constraints, many must be left for future research.

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The nature of several proposed "directions" of further research can, however, be briefly suggested.

First, with regard to the "computerization" of the procedures, the author suggests that this remains a distinct possibility. Of course, this would first require a precise data base which, in turn, calls for the careful monitoring of the residential-address information provided by consumers of power, gas, and telephone service since these services are either initiated or terminated in conjunction with a change of residence. Census data banks could be tied into a chain-construction and plotting algorithm to provide a spontaneous view of both the nature and spatial characteristics of the vacancy chains initiated in any neighborhood in the city. In other words, mobility patterns could automatically be related to the social and economic characteristics of the city to provide a complete "urban social geography." If such procedures are to be attempted, though, the writer recommends more than one year's data to increase the probability of linkage completion. It seems that such a computer package would indeed be a powerful weapon in a planner's "arsenal," especially in the sense of guiding new residential construction to best benefit specific low-income areas of the city.

Two areas of research were briefly mentioned earlier in the text, though they were beyond the scope of the present work. One involved initiating vacancy chains in a few large multiple-unit structures in order to investigate the rental system of a city. Interesting patterns of movement may surface here and lead to a better understanding of that particular housing submarket. The other suggestion made earlier but not studied in this work relates to the areal and temporal
characteristics of the vacancies themselves. Are there spatial patterns to the temporal durations of vacancies? Can these patterns pinpoint zones of potential decline? The author feels that these two areas of investigation, readily done with the use of vacancy chains, could prove lucrative.

The application of the technique of "simulation" may provide additional knowledge about the geographical aspects of intra-urban vacancy chains. Comparing an actual spatial pattern of vacancy chains with others generated under random conditions should at least allow one to assess the importance of the local environment in influencing the empirical patterns of chains.

Though the difficulties in obtaining a precise data set may prove prohibitive, the methodology outlined in the preceding chapters should probably be tested in a larger city. It would indeed be interesting to compare the findings of such a study to those of this work. At the same time, though, a study done in another city the size of Lincoln could also be compared meaningfully. Even a study focusing upon Lincoln but done using 1962 data would be interesting and may be valuable.

Finally, the important finding of this work regarding "reverse-filtering" needs to be investigated further. This area of research holds much promise.

Many other possibilities for further research have occurred to the writer at one time or another during the accomplishing of the present work. These few mentioned here, though, are considered to be the more significant examples.
Concluding Remarks

The actual conclusion of a study such as this is a formidable task. Because the approach and techniques are clearly exploratory, the conclusions serve only as a beginning. The author is convinced, however, that the methods outlined in this work are capable of initiating a whole new thrust in research on intra-urban migration. Modifications in or additions to the procedures may be beneficial and are certainly welcomed. It is firmly believed, though, that the distinctly geographical concept of the vacancy chain is one worthy of the current effort and of continued research.
Definitions

The terms listed below are important in understanding the vacancy-chain procedures described in the text. They are ordered in a sequence which is thought to allow the greatest comprehension (asterisk* = terminology mine).

Vacancy chain - A series of related moves constructed by linking individual vectors which connect the origin and destination of each change of residence in the series. A vacancy chain consists of at least two vectors with the first link being an intra-urban move. The term is used synonymously with "linkages."

Link - An individual vector in a vacancy chain. It is the straight line connecting the points of origin and destination (shortest path) of one intra-urban move. Links are numbered beginning with the "foundation ingression" to an "initiator cell," which is Link #1.

*Initiator cell - A contiguous set of sample blocks which constitute all or part of a census tract. It is taken to be representative of a "neighborhood." Moves to the initiator cells are used to "initiate" vacancy chains.

*Initiator block - One of the sample blocks in an initiator cell.

*Cell ingression - An initial move into an initiator cell. It may be intra-urban, intra-state, inter-state, or inter-national. If the intra-urban ingression leads to the construction of a vacancy chain, it is then referred to as a "foundation ingression." If it does not lead to the construction of a vacancy chain, it is simply termed a "non-foundation ingression" to a particular initiator cell.

*Foundation ingression - The intra-urban move into an initiator cell which initiates the vacancy chain. It can be caused either because of a previous change of residence in an initiator cell or new construction. It is the first link in a vacancy chain and is sometimes termed simply as the "foundation move."

*Non-foundation ingression - An intra-urban ingression to an initiator cell, but one which did not, for various reasons, initiate a vacancy chain. In other words, this particular vector could not be "tied" to others.

*Cell egression - A move out of an initiator cell. It may be intra-urban, intra-state, inter-state, or inter-national. This move creates a vacancy which is eventually filled by a cell ingression which may in turn become a foundation ingression.
In-migration - A change of residence in which the migrant moved into a city (but not to an initiator cell) from outside of the corporate limits. If the move was to an initiator cell, it would be termed a cell ingression. The move may come from out of state or even out of the country. It is often a reason for the termination of an intra-urban vacancy chain.

*Beneficiary area - The neighborhood in a city that eventually benefits in terms of freed housing, either from new construction of residences on the urban periphery or out-migration from these more peripheral locations. Certain neighborhoods "benefit" because vacancies "move" to them due to the filtering process and more housing becomes available for certain groups, e.g., low-income persons.

Feeder cell (or neighborhood) - A "neighborhood" from which migrants typically move. It is a common or popular origin point for movers.

Receptor cell (or neighborhood) - A "neighborhood" to which migrants typically move. It is a common or popular destination for movers.

Intra-urban circulatory system - The predominant intra-urban mobility flow pattern in a city. It is the composite of all feeder-receptor cell linkages.
### TABLE 1

"ADDRESS EVALUATION" FOR APARTMENTS

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Number of Units</th>
<th>Moves In</th>
<th>Without Apartment Number</th>
<th>Moves Out</th>
<th>Without Apartment Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carribean Apts.</td>
<td>1215 Arapahoe</td>
<td>96</td>
<td>88</td>
<td>7</td>
<td>46</td>
<td>39</td>
</tr>
<tr>
<td>Briarhurst</td>
<td>4600 Briar Park</td>
<td>108</td>
<td>58</td>
<td>2</td>
<td>87</td>
<td>71</td>
</tr>
<tr>
<td>Century House</td>
<td>1201 J</td>
<td>97</td>
<td>17</td>
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<td>Town and Country</td>
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<td>68</td>
<td>23</td>
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<td><strong>28</strong></td>
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### TABLE 2

"ADDRESS EVALUATION" FOR TRAILER PARKS

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<th>Name</th>
<th>Address</th>
<th>Number of Lots</th>
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<th>Without Lot Number</th>
<th>Moves Out</th>
<th>Without Lot Number</th>
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<tr>
<td>Center Court</td>
<td>4000 Cornhusker</td>
<td>181</td>
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Books


Periodicals


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<th>Title</th>
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Theses and Dissertations


Miscellaneous Sources


"Daily Moving Record." Compiled and Published by The Credit Bureau of Lincoln, Nebraska, Inc., Volume 59, 1972.


Doucet, Michael J. "Nineteenth Century Residential Mobility: Some Preliminary Comments," Discussion Paper #4, Department of Geography, York University, Toronto, Canada.


"Listing of Multiple-Unit Structures in Lincoln." Published by the Office of the Housing Administrator, Lincoln, Nebraska, February 9, 1974.


1970 Census of Population and Housing. Lincoln, Nebraska Urbanized Area.

Newspapers and Related


"1,000 Acres Zoned for Multiple Dwelling." Lincoln Journal, Lincoln, Nebraska, Monday, February 12, 1973, p. 7.